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Cross-Language Treatment of Speech Sound Disorders in Bilingual Children

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Cross-Language Treatment of Speech Sounds Disorders in Bilingual Children

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Dedication

I dedicate this work to my mother, Isabel Pérez, who inspired me to reach for the stars.

Bendición, Mamá. Te quiero mucho.

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Abstract

Cross-Language Treatment of Speech Sound Disorders in Bilingual Children

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The purpose of the present study is to explore generalization of knowledge across languages when treating speech sound disorders in bilingual children. Phonological knowledge interacts across phonological systems. Thus, in theory, treating phonetic aspects that are shared across the sounds of differing languages should facilitate target accuracy in each of the child's phonological systems. Addressing both linguistic systems allows clinicians to support the communication of their clients across linguistic environments.

Specifically, this study seeks to answer the question: Can cross-linguistic generalization be facilitated for targets with shared phonetic features in Spanish-English bilingual children with speech sounds disorders? The hypothesis is that shared phonetic features are subject to interactional effects. To test this hypothesis, four bilingual children between the ages of 5;0 – 6;6 with speech sound disorders participated in a phonological intervention with individualized treatment goals. Each child received therapy focusing on the shared features across phonological systems in their home language (Spanish) and their second language (English). Accuracy of targeted sounds was the dependent variable and was assessed within and across languages using a multiple-baseline-across-behaviors, single-subject design. The prediction was that skills targeted in Spanish would generalize into English.

The results show concurrent growth across phonological systems when treatment was administered only in Spanish. This study offers insights into how bilingual children categorize shared features across languages and how treatment can be facilitated in one language to promote generalization of skills both internally and externally. The implications affect how we create goals in a clinical setting and support an interdependent model of phonological organization in bilingual children. Future studies may wish to explore reverse directions of generalization and generalization across other language combinations.

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Chapter 1: Introduction

Speech sound disorders interfere with a child's ability to accurately produce the sounds of their language to communicate. The inability to accurately articulate can have a significant impact on the quality of life of a child (Markham & Dean, 2006) and typically requires treatment. The treatment of speech sounds disorders in bilingual children requires consideration of both phonological systems and an understanding that the bilingual child's phonological systems are interconnected across languages. Sounds within systems may be similar enough to cause interactional effects across systems. One approach to address skills in both languages is to provide treatment that utilizes the shared phonetic qualities of similar sounds to promote generalization of skills from one language into the other. Early evidence (Dodd & Holm, 1997; Dodd & Holm, 2001; Gildersleeve-Neumann & Goldstein, 2015; Ray, 2002) demonstrates generalization of skills is possible. Given the ever-increasing population of speakers of more than one language, increased understanding of cross-linguistic generalization is warranted as clinicians would be better informed as to whether and how targeting one language could facilitate growth in the child's other language(s).

1.1 Phonological Organization Across Languages

Phonological systems may be structured in different ways in the bilingual brain. Grosjean (1997) in the Bilingual Model of Lexical Access argues that languages form independent subsystems within a greater connected language system. These elements include the phonemes and phonetic features of each language. Evidence for differentiation comes from a variety of studies. For example, bilingual children know translation equivalents, which differ from cognates by not necessarily having the same phonological form, early in their development (De Houwer, Bornstein, & De Coster, 2006; Junker & Stockman, 2002). Infants also respond differently to the rhythmic properties of two languages they are exposed to (Nazzi, Bertoncini, & Mehler, 1998). However, children likely differentiate between two languages they are exposed relatively early (Genesee, 1989).

Although languages are differentiated, there is also evidence for connection between phonological systems at a phonetic level where elements within or across subsystems can influence one another. In the Speech Learning Model, Flege (1995) posits that phonetic elements share a space common to both languages phonologically and, therefore, interactional effects will be seen across languages. This interactional effect can occur when either a new category fails to be formed or the first language (L1) and second language (L2) categories merge. Flege (1987) demonstrated how voice onset times merge in French in English for /t/ with French-English bilinguals producing intermediate onset times between the two languages. This merging of phonetic differences is an example of phonetic category assimilation.

From a position of interdependence, interactional aspects may result in transfer, deceleration, or acceleration (Paradis & Genesee, 1996). Transfer occurs when the properties of one language are incorporated into the other. For example, Spanish-English bilingual children may substitute the retroflex /ɹ/ for the Spanish trilled /r/ when there is a discrepancy in skills. Deceleration occurs when a skill emerges later than would be expected. For example, in the area of phonology, Gildersleeve-Neumann et al. (2008) revealed decelerated performance of production of speech sounds in Spanish-English bilingual children as measured by production accuracy of performance, which although still within a typical range, was lower as compared to their monolingual English-speaking peers. Acceleration occurs when a skill emerges more rapidly than would be expected in comparison to monolingual children. Increased rates of acquisition have been noted in German-English (Maiwald & Tracy, 1996) and German-Spanish bilinguals (Kehoe et al., 2001; Lleó et al., 2003).

Interactional processes may be the result of bilingual children categorizing phonetically similar sounds into one phonemic category (Goldstein & Fabiano-Smith, 2010). The advantage of organizing two phonemes that share features across systems into one category might lie in quicker access to the sounds and increased experience in producing them. This explanation is supported by data demonstrating bilingual children also demonstrate skills that lie within a typical range as their monolingual peers (Goldstein & Washington, 2001; Goldstein et al., 2005; Paradis & Genesee, 1996). More specific to phonological interaction, when performance is measured by percent consonants correct, data consistently reveal bilingual children perform with higher accuracy for phonemic sounds that share phonetic properties (Fabiano-Smith & Goldstein, 2010; Montanari, Mayr & Subrahnmanyam, 2018, Nye et al., in review). In addition to sharing phonemic categories, higher accuracy could be influenced by additional experience in production compared to sounds uniquely categorized in only one language.

1.2 Facilitating Growth Across Languages

Treatment of speech sound disorders in bilingual children requires addressing error patterns in both languages. Although distributional differences will be seen, bilingual speech-sound disorders will manifest across languages in similar ways (Goldstein & Gildersleeve-Neumann, 2012). For example, for a Spanish-English bilingual child who reduces consonant clusters, cluster reduction will be seen in both Spanish and English. Although, the process of reducing clusters is likely to impact English differently, as the phonological system of English allows and uses clusters to a greater degree, the need to address the skill in both languages remains present.

From a therapeutic standpoint, interactional effects between shared phonetic aspects could be manipulated to promote generalization across languages to address skills in both languages. For example, voice onset times differ between Spanish and English plosives /k/. Typical English production consists of a delay in voice onset time characterized by aspiration [k^{h}] (when not preceded by /s/) whereas Spanish production is near zero [k$^{=}$]. Both phonetic productions share place of articulation (velar), manner (stop), and are generally considered to be voiceless sounds, however. Consequently, these sounds might share enough phonetic features so that bilingual children would place them within the same phonemic category of /k/. Therefore, treating either [k^{h}] or [k$^{=}$] might manifest in higher accuracy of /k/ across Spanish and English. For other sounds, such as /s/, cross-linguistic generalization might be facilitated more directly, as phonetic production is nearly identical. On the other hand, sounds like /r/, might generalize more slowly or not at all due to the greater amount of phonetic differences. Some sounds exist in both languages but are allophonic in nature, such as the flap /ɾ/ (e.g. *caro* vs. *carro*), which is phonemic in Spanish but arises as an allophone of /t/ and /d/ in English (e.g. butter). It is unclear how bilingual children will categorize these sounds, but second language learners will often substitute /ɹ/ for the flap, choosing the phoneme with the closest phonetic features. The reverse is true in Spanish /d͡ʒ/, which arises only as an allophone of /j/ and is often replaced with the latter in English by L2 learners.

Table 1 summarizes one way in which phonemes across Spanish and English can be categorized based on shared phonetic features. Allophones that are phonetically similar are bolded, though these may vary per variety of Spanish. This categorization is based on Latin American Spanish, which was the variety spoken by the participants of our study.

We refer to the ability to generalize a sound across systems as cross-linguistic generalization. Treating /s/ only in Spanish and observing accuracy of performance increase in both Spanish and English would be an example of cross-linguistic generalization. Similarly, treating consonant clusters in Spanish and seeing accuracy of consonant clusters increase in both Spanish and English would be an example of the same. In both cases, a child would have used their knowledge gained in one language and generalized the skill into the other language. The generalization occurs when this skill was not directly trained yet performance increases independently in this other (e.g. second) language.

1.3 Treating Speech Sound Disorders in Bilingual Children

By choosing targets with shared phonetic aspects across languages, early studies suggest that it is possible to facilitate growth of skills in both languages of bilingual children with speech sound disorders. For example, Holm and Dodd (1997) attempted to facilitate cross-linguistic generalization from English into Cantonese when treating /s/ distortions and liquid blends in English. They observed progress in English and in Cantonese for /s/ but did not see any progress in Cantonese for liquid blends. However, as Gildersleeve-Neumann and Goldstein (2015) note, Cantonese is not typically associated with clusters, which may have been the reason for the lack of generalization of clusters even when /s/ generalized to Cantonese. This illustrates the importance of phonetic overlap across the systems in target selection.

Cross-linguistic generalization may be possible at the sequencing level as well. Holm and Dodd (2001) attempted to facilitate cross-linguistic generalization in a 4;8 year-old, Punjabi-English bilingual who had difficulties producing phonological sequences across languages. Using a Core Vocabulary approach, their data showed increased accuracy of consonant production from pre-test to post-test measures based on treatment in English only. Gildersleeve-

Neumann and Goldstein (2015) also saw cross-linguistic generalization for a 5;6-year-old, Spanish-English bilingual boy with Childhood Apraxia of Speech (CAS) when treating stop + liquid clusters using dynamic temporal and tactile cueing (e.g. articulatory cues, delayed rates, etc).

Cross-linguistic generalization of growth may be possible in more than one language. Ray (2002) treated a trilingual child with multiple phonological processes that was exposed to Hindi, Gujarati, and English (L3). Ray (2002) observed a decrease in shared phonological processes in English and overall decrease in percent consonants correct in all three languages using a cognitive-linguistic (minimal pairs) approach in English. Unfortunately, while detailed information regarding the phonological processes was given for pretreatment performance, it was not provided post-treatment. Nevertheless, pretreatment versus posttreatment performance suggests targeting shared phonological processes can promote cross-linguistic generalization.

Another way to facilitate cross-linguistic generalization is to work in the L1 and provide smaller doses of therapy in the L2. Gildersleeve-Neumann and Goldstein (2015) demonstrated growth in both languages through administering treatment in Spanish and English for /s/ clusters. Growth was seen in both languages despite a larger dosage to the dominant language (Spanish). For one child, 12 sessions were conducted in in Spanish and three in English. For the second child, 15 sessions were conducted in Spanish and 5 in English. Treating shared processes and sounds with shared phonetic features within those processes did result in generalization of skills across languages, as growth was commensurate across languages despite lower doses in English relative to Spanish for targets. Their use of a multiple-baseline-across-behaviors design allows us to make a stronger conclusion that generalization is indeed possible.

Some of the examples above suggest that complete phonetic overlap may be necessary for transfer. However, Gildersleeve-Neumann and Goldstein (2015) considered if choosing sounds from the same phonetic class would be sufficient to support generalization. They targeted consonant (liquid) blends in a 5-year-old, Spanish-English bilingual child. They did not provide specific examples of stimuli but in both Spanish and English /l/ and /r/ are liquid consonants. The /l/ has identical phonetic features across languages. The /r/ differs between English ([+] retroflex) and Spanish ([+] trill) and is considered an unshared sound in earlier work (Fabiano-Smith & Goldstein, 2010). Nevertheless, cross-linguistic generalization was seen and the effect size was large (d=3.173). From these findings, we might predict lower levels of phonetic overlap could still result in less generalization across languages. That is, while /r/ differs phonetically in manner across languages, it does share the features of place ([+] alveolar), voicing ([+] voiced), and similar levels of sonority. In such cases, partial generalization or transfer could be possibilities.

Level of phonological knowledge may influence rates of cross-linguistic generalization. In a pilot study, Nye (2016) examined the effects of utilizing a minimal pairs approach to treat clusters across English and Spanish. Two four-year-old boys received weekly speech therapy targeting the error patterns of cluster reduction with /fl/ clusters. This cluster shares phonetic features across Spanish and English. For both children, these were sounds that were least stimulable and not produced in isolation (e.g. /f/ or /l/). Stimulability was measured by the children's ability to modify speech production when given a model (Powell & Miccio, 1996) and is one form of phonological knowledge. After 6 sessions, the children produced /f/ in the language of treatment; no change was observed in clusters or across languages. This rate of progress for non-stimulable sounds for bilingual children is consistent with the outcomes documented for monolingual children in which gains may not be observed until 12 sessions (Geirut et al., 1996; Geirut & Morrisette, 2012). That is, rate of change may affect rate of generalization across languages, as nonstimulable items may take longer to generalize (Geirut, 2001). In stimulable items, we may see change quicker. If trends are consistent with monolingual gains, this may occur within six, 40-minute sessions (Rvachew & Nowak, 2001).

1.4 Summary and Limitations of Previous Research

The previous studies have attempted to promote generalization across languages working in both the L1 and the L2. These studies have looked at generalization from English (L2) into the home language (L1) and a combination of working in the home language (L1) and English (L2). The majority of the studies (Holm & Dodd, 1997; Holm & Dodd, 2001; Ray, 2002) have done so primarily through case studies using pre-test and post-test measures.

The findings from these studies in general suggest skills in one language can generalize into a second. Holm and Dodd's work (1997, 2001) suggests phonetic skills will generalize into the L1from the L2 for singleton targets that overlap in phonetic features (e.g. /s/). Ray's (2002) work suggests treatment effects can even be seen across more than one language. Gildersleeve-Neumann and Goldstein's (2015) study indicates generalization can occur for phonological targets with treatment in the L1 and a few scattered sessions in the L2. Specifically, generalization was seen for targets that overlapped fully and partially in phonetic features but fell within a broader syllabic structure that overlapped across phonological systems (i.e. consonant + liquid in Spanish and English). Targeting syllabic constructs that do not overlap across systems (i.e. consonant + liquid) as in Holm and Dodd (1997) between Cantonese in English did not result in treatment gains. These studies used a variety of treatment methods but across each study cross-linguistic generalization was seen when targets sufficiently overlapped phonetically across systems and respected the phonological constraints of each.

Taken together, the results from the early studies (Dodd & Holm, 1997, 2001; Ray, 2002) have limited applicability to current practices. Their designs serve as case studies and the details reported do not allow us to replicate their findings. With the exception of the most recent study by Gildersleeve-Neumann and Goldstein (2015), the studies do not report treatment targets, details on treatment techniques, track treatment progress, and give few details to the type of bilinguals or the practitioners themselves. Poor ability to replicate compromise most of what we know about treating bilingual speech sound disorders in children. Furthermore, none of the above studies were designed to examine the effects of treating only in the home language, in our case Spanish. We acknowledge that bilingual treatment of speech sound disorders is the gold standard (Goldstein & Gildersleeve-Neumann, 2012) to ensure that the child will be a competent communicator in all environments. From a clinical perspective, however, knowing if linguistic skills will generalize across language by treating only one set of targets in one language remains particularly beneficial, as it might aid in efficiency of treatment progress. It still remains to be demonstrated experimentally if working only in the L1 can facilitate cross-linguistic generalization into the L2, and attempting to establish generalization by working only English has proved more difficult than it might appear (Holm & Dodd, 1997; Holm & Dodd, 2001).

Alternatively, approaching treatment in the language that the child knows best (L1) into the L2 offers an opportunity to examine role of each language from a new perspective. We have strong evidence that treatment primarily in the L1 (Spanish) with some treatment in the L2 (English) does in fact promote cross-linguistic generalization (Gildersleeve-Neumann & Goldstein, 2015). We do not know if treatment only in the L1 will promote similar change. If we wish to continue to employ the same rigorous forms of scientific documentation, examining if we can promote gains in English by treating only Spanish is a logical next step in our understanding of cross-linguistic generalization.

1.5 Specific Aim

This study seeks to answer the following question:

Can cross-linguistic generalization of speech skills from Spanish to English be facilitated through treating the shared phonetic qualities of targets in Spanish?

We predict that targeting areas of phonetic overlap across languages will result in generalization in a cross-directional manner; in this case, specifically from Spanish to English. This study focuses on treating the dominant (home) language where phonological skills are likely to be the strongest. The current hypothesis is that treating both languages may not be necessary if the phonological targets overlap to a sufficient degree at the phonetic level.

Chapter 2: Methodology

2.1 Assessment and Selection Criteria

This study was approved by the Institutional Review Board of the University of Texas at Austin. Seven participants were recruited from the greater Austin area via flyers and word of mouth. Children with languages delays were included in the study due to the high rate of concomitant delays across domains of speech and language. However, children with diagnoses known to include cognitive delays (e.g. Down Syndrome, Autism) were excluded due to the nature of the therapy, which utilized a cognitive-linguistic approach (see below). Two children did not meet the criteria and one child presented with a speech delays secondary to a cleft palate but was not enrolled since the nature of his errors did not fall within the scope of the current study. Four participants were ultimately enrolled in the study. These four participants were referred by other bilingual members of the community.

Participants were between the ages of 5;0 and 6;5, the ages within which it is consistent to identify and treat speech delays in a school or clinic setting. Assessments took place either at the home of the family or at the university speech and hearing center. Transportation and work schedules were an obstacle for all of the families who likely would not have participated if services were conducted only at the university, as some lived as far as 1 hour away and worked multiple jobs or were without vehicles. No compensation was given; however, all services were provided at no cost to the family and families received copies of evaluation reports if desired. Participants and families were instructed that they were free to discontinue services at any time.

Participants received a speech evaluation along with a language and hearing screening. Participants were evaluated by the principal investigator, who was a licensed, bilingual speech-language pathologist holding ASHA certification. Participants were administered the assessment protocol that was appropriate for their age. For example, participant 3 was age 5;0 at testing and received the BESA phonology subtests. Participant 1, however, was above the age of 6 and received the CPAC-S in Spanish and BESA phonology subtest in English. Assessment measures are listed in Table 2.

Stimulability was also assessed using nonsense syllables given with a single model (e.g. *Say* /kra/) in the language of treatment (i.e. Spanish) based on previous monolingual research (Goldstein, 1996; Rvachew, et al., 1998), as no known stimulability research has yet to be conducted with bilingual children. Syllables contained the shared phonological structures of CV and VCV shapes. No VC combinations were used, except for with /s/ that was later added (see participant 3 profile), as that syllabic structure is less frequently occurring in Spanish and limited to only a few permissible phonemes (i.e. /d, n, s, l, r/) in word-final position. Vowels used were the vowels /a, e, i, o, u/, which overlap in phonetic features of height, advancement, and tenseness. In total, 10 items were presented (5 vowels x 2 syllable forms), with an additional 5 for participants 3, as listed in Appendix 1. Targets selected were those with less than 60% stimulability to avoid spontaneous recovery based on the work of Carter and Buck (1958) and Diedrich (1983). Initial targets were based on Rvachew et al. (1998) demonstrating targeted sounds that were developmental in nature and stimulable at least once at the syllable level saw mean production scores of 53% accuracy on later probe stimuli. Goldstein (1996) targeted sounds that were 30% stimulable (3/10) in syllables with Spanish-speaking children and saw 50% accuracy on later probe stimuli for target words.

Participants enrolled in the study demonstrated clinically significant phonological delays across languages and hearing within normal limits as indicated by passing pure tone screening at 20dB at 1000, 2000, and 4000Hz. A clinically significant delay was based on published sensitivity and specificity specific to the Bilingual English Spanish Assessment (BESA) phonology subtests, Contextual Probes of Articulation Competence Spanish (CPAC-S), parent report (interview, language use, and case history) and a relational analysis of errors. Standardized cutoffs are presented in Tables 3-5. Children were selected that also exhibited profiles consistent with a bilingual speech sound disorder (i.e. positive parental concern, low PCC, decreased intelligibility, errors present across languages, and any presence of atypical errors (Goldstein, 2012)). The use of additional factors was used to support standardized testing results and the use of parent interview is consistent with research indicating the questions “Do other people think your child is hard to understand?” and “Do other people think your child has speech problems?” accurately predicted phonological skills in Spanish-English bilingual children (Goldstein et al., 2010). As the BESA did not meet sensitivity cutoffs for six-year olds in Spanish, any Spanish-dominant participants at that age were also administered the CPAC-S in Spanish.

Two volunteer undergraduate participants assisted with data collection and cultural convergence, as the primary author was of Puerto Rican descent and the families in the Austin area were primarily of Mexican heritage. Both were heritage Spanish speakers of Mexican descent. The first was a senior whose major was Spanish and Communication Disorders. She was born and raised in San Antonio. The second was a junior whose major was Communication Disorders and was born and raised in Austin. Both volunteers had taken the departments Clinical Phonetics course. Volunteers assisted in community outreach, disseminating flyers, selecting and creating materials, presenting stimuli during testing and therapy activities, double scoring, and post-treatment reliability.

2.2 Design

This study employed a multiple-baseline-across-behaviors design. The across-behaviors component was selected to maintain internal validity. A single-subject research design was chosen for multiple reasons. First, it most closely replicates clinical therapy in which one participant is generally seen at a time with multiple participants possessing similar profiles on a caseload, and multiple goals being formed. Second, a single-subject design was an optimal starting point for treatment research in this area due to the lack of previous bilingual studies. It was ideal for the experimental question at hand and our current state of knowledge in the field. Participants passed through a baseline phase, a treatment phase, and depending on targets, a maintenance or generalization phase. A minimum of three data points were collected for each child during baseline and treatment phases in addition to a pretest and posttest data.

For Participant 2 and 3, a delayed, multiple-baseline across behavior design was implemented. A delayed-multiple baseline starts either at or after treatment has occurred but before a change in the dependent variable is seen. This design is ideal when practical difficulties make a full-scale design difficult or a new behavior becomes available (Heward, 1978). Participant 2 initially began treatment under a standard multiple-baseline-across-participants design in which one behavior was assigned to each participant; subsequent goals were added for experimental control when that design shifted. Participant 3 received an additional goal after treatment had begun. A delayed multiple-baseline maintains control when the additional behaviors stay stable even when introducing the independent behavior to the first behavior and a response is replicated upon initiating treatment.

The selection of multiple participants (4) for this study was chosen to enhance the external validity of this study. By recruiting multiple participants, we helped to mitigate the cost of any attrition. In addition, replication of the findings across different types of behaviors, in this case articulatory and phonological, with 4 different participants with varying profiles (e.g. age, phonological knowledge, exposure), in multiple settings (i.e. individual homes of each family), defends against the possibility findings seen were isolated in nature, as this study includes generalization variables in its design.

To maintain a high level of social (i.e. ecological) validity, we chose materials, approaches, and dosages that would be easily replicable by a master's level clinician practicing in a clinical or school-based setting (see 2.3 (dosage), 2.5 (treatment), and 2.6 (stimuli)). Furthermore, our dependent variables were of high social importance, as the accuracy of speech productions can impede intelligibility and cause social stigmas (see 2.4 (targets). In addition, all of our stimuli are provided in Appendices 1 – 5 for purposes of replicability and raw data points are presented in Figures 1 - 4.

To assess our results, we graphed our data across behaviors for each phase and used visual analysis, which included analyses of mean levels of performance, trends (i.e. rate of increase or decrease), consistency of patterns (i.e. degree of fluctuation) across phases, immediacy of effect following introduction or withdrawal of the independent variable, proportion of data in adjacent phases that overlap, and magnitude of changes. We used guidelines presented by Horner et al., (2005), Cook et al., (2014), and What Works Clearinghouse (2014). We sought to establish experimental control, defined by 3 demonstrations of the effect at 3 different time points with replication across two behaviors within the same participant. In addition, we used criterions and a cost-benefits assessment to assess the meaningfulness of our findings.

2.3 Treatment Dosage

Participants participated weekly intervention sessions conducted by a bilingual speech-language pathologist (main author) at their homes. Again, this was chosen as the place for therapy due to lack of access to the university clinic by families. It is important to note, however, that, as a result, therapy was conducted in living rooms, on the floor, or while other activities were going on in the home. At times, this created distractions that may have lowered performance or treatment effects. Therapy was play based in nature, and incorporated games and production of sound targets between or during turns. Therapy sessions lasted 50 minutes with a total of 10 minutes for probe data collection, 35 minutes for intervention work, and 5 mins of parent consultation or general activities. If a child missed a session, that session was made up with an extra session whenever possible (ideally during the same week). Participants 1 and 2 were seen once a week and produced 75 – 100 target trial productions per session per target for each phase. Participants 3 and 4 were seen twice a week and produced approximately 50 trial productions per target per session per phase. The higher dosage of productions for Participant 1 matched age-level abilities and for Participant 2 the motoric nature of her errors. The lower productions for Participants 3 and 4 matched the lower stimulability and their age-level abilities. Once treatment shifted to the next phase of the next goal, the number of productions produced for the previous goal decreased based on time constraints and the performance of the child (see participant profiles). This therapeutic intensity and frequency matches that commonly available in school-based and clinical settings and was used in Gildersleeve-Neumann and Goldstein (2015) study. A goal was discontinued when performance reached a criterion of 80% accuracy in each of 2 sessions and 3 replications of an effect during the treatment phase was seen. The 80% accuracy was based on the 75% criteria of Geirut and Morisette (2010) for productions during imitation phases of treatment.

2.4 Treatment Targets

Treatment targets were consonants and clusters presented in words in the language of intervention (Spanish) and probe targets were the same presented in the language of generalization (English). Targets were drawn from commonly used resources in Spanish and English (see each participant for specific details). Number of targets varied per child but the minimum of 3-5 targets were selected for each goal. Selection of words was based on the work of Elbert, Powell and Swartzlander (1991) indicating three to five targets are sufficient for generalization within languages. The addition of additional targets was to document growth at a finer level and statistical consultation indicating additional exemplars would be needed for any potential statistical analyses.

Treatment targets were tailored to the phonological system of each child. It is important to note, that all children in the study presented with speech and language delays. As such, independently naming stimuli was too difficult of a task for most items for the children. Targets were set at a linguistic level that matched the abilities of the child and produced with imitation. Words were presented to the children in a neutral manner without prompts or cues, although therapy practice included both in Spanish. Importantly, this is different from Gildersleeve-Neumann and Goldstein (2015), in which prompts were given to use their practiced sounds during probe trials. As such, probe data in our study represent an additional level of linguistic generalization within the treatment language during baseline and for sessions afterward until target behaviors had been established to a high enough skill level to be seen without a prompt.

During baseline conditions, reinforcement was only given only for participation in the task, not for accuracy of performance. During treatment conditions, correct productions were followed by verbal praise and tailored feedback (e.g. “I heard you make a /s/ sound.”). A sticker reward was given to the child for completing each activity and the child collected these to earn a choice from a prize bag. Correct productions were tallied by the treating clinician. Incorrect productions were followed by scaffolding correct responses, including direct models, verbal cues, or visual aids.

2.5 Treatment Stimuli

Treatment targets were 10 words in Spanish, the language of treatment, and generalization targets were 10 words in English for most target behaviors, with the exception being for Participant 2 who had 15 treatment targets (3 sets of 5) and 15 generalization targets (see below). Again, selection of at least 5 words is based on the work of Elbert, Powell and Swartzlander (1991) indicating three to five targets are sufficient for generalization. The addition of additional targets was to document growth at a finer level based on pilot data and statistical consultation indicating additional exemplars would be needed for any potential statistical analyses.

Treatment stimuli were all words drawn from commonly used therapeutic materials, with the exception of Participant 2, for which stimuli did not exist. Stimuli lists were pulled from "Dilo asi" for Participant 1, were created by the author for participant 2, and were selected from Super Duper© phonological cards in Spanish and mommyspeechtherapy.com in English for Participants 3 and 4. The Super Duper © cards were minimal pairs in Spanish while the English stimuli were not in pairs since they were generalization targets. Participant 4 additionally had "ch" stimuli selected from CASA-Artic © and Articulation Station © therapy (iPad) apps. These stimuli were intentionally chosen because they matched the phonological targets of the study and were easily accessible to practicing clinicians for purposes of replicability. Stimuli were presented on flashcards using original artwork whenever possible. In cases where this was not possible, drawing were created using LessonPix © flashcard stimuli. The stimuli included drawn representations of the target words and vocabulary that fell within the age range of the participant that also included the target sounds or patterns. Stimuli for all children are presented in Appendices 2 – 5.

2.6 Treatment Approaches

Important consideration must also be given to the method of treatment. The type of treatment administered could also have a role in transfer across languages. Existing approaches fall generally into either sensory-motor approaches or cognitive-linguistic approaches (Bernthal & Kankson, 1993). For isolated or atypical error patterns, a sensory-motor approach may be most applicable (Van Riper, 1972). For children with widespread errors, cognitive-linguistic approaches are generally recommended (Geirut, 1998). These treatment approaches seek to shift the phonological system in some manner by drawing awareness to the patterns of sound errors (Geirut, 2001). Thus, phonological approaches choose targets with reference to the overall pattern of errors and productions within the system. This same system shift could spread across languages from interactional effects (Goldstein and Fabiano, 2007).

For the purposes of cross-linguistic transfer, both methods could promote generalization through either motoric or conceptual learning. Sensory-motor (traditional) approaches are supported by research in both monolingual (Elbert & Mc Reynolds, 1978; Elbert, Powell, & Swartzlander, 1991; Hoffman, 1983) and the previously described bilingual studies (Holm & Dodd, 1997; Holm & Dodd, 2000). Cognitive-Linguistic approaches are firmly established for clinical intervention with monolingual children, particularly utilizing a minimal-pair treatment approach (Ferrier & Davis, 1973; Gierut, 1989; Gierut & Neumann, 1991; Saben & Ingham, 1991; Tyler, Edwards, & Saxman, 1987; Weiner, 1981), and also in the previously described studies (Gildersleeve-Neumann & Goldstein, 2015; Ray, 2002). Phonological approaches continue to be the method most supported by research for children with patterns of phonological errors in general.

The breadth of monolingual research continues to suggest promising results using cognitive-linguistic and sensory-motor approaches to treat speech sound disorders depending on the type of target. Furthermore, there is also present, the albeit smaller, body of research to use these intervention approaches with bilinguals. Ray (2002) and Gildersleeve-Neumann and Goldstein (2015) both used cognitive linguistic approaches and reported cross-linguistic transfer. Gildersleeve-Neumann and Goldstein (2015) included an additional meta-linguistic element. Children were taught that the target sounds were present in both of their languages, highlighting the overlap between phonological systems. In addition, a combination of motoric and phonological components was used effectively to treat both motoric and phonological delays in their study.

We chose treatment techniques that were tailored to the pattern of error and needs of the child based on these findings. All four children presented with speech sounds disorders phonological in nature with error patterns across both languages. It's important to note that a clear distinction between sensory-motor and phonological was not see for all treatment targets and participants. Treatment approaches combined phonological and articulatory strategies to achieve treatment gains consistent with the needs of the child. The basic components of these approaches were based on strategies known to be effective for children with speech sound disorders and included a) mass practice of target sounds (Edeal & Gildersleeve-Neumann, 2011; Skelton, 2004) b) phonetic cueing for articulatory placement and c) phonological contrasting of targeted and errored sounds using minimal pairs (Weiner, 1981).

Activities were play-based in nature and trials given in a turn-taking fashion. Minimal-pair activities included matching and requesting games. Articulatory activities were paired with age-appropriate games such as Candy Land ©, Hi-Ho Cherry-O ©, and Chipper Chat © boards. During each activity, children were scaffolded through the treatment activities so that no activity resulted in a score of less than 70% accuracy. If more than 3 errors were made in 10 trials, the linguistic level of work was lowered to one that child could produce more consistently (e.g. syllables to sounds). Once a child demonstrated an accuracy of 70% or higher, the difficulty of the activity was increased (e.g. sounds to syllables). Targets were trained beyond the level of words when possible (i.e. phrases) to help promote generalization, particularly for probe tasks, since the latter were completed without a prompt. Levels of scaffolding are based on Hegde (1998) and provided in Table 13.

Children were lead through activities using a visual schedule and sticker-reward systems. For completing an activity, participants earned a sticker that was in turn traded for a reward (i.e. *premio)* at the end of the session that consisted of small, age-appropriate toys (e.g. bouncy balls, sticky hands, pencils, etc). If a child was struggling with attention, they were given a 1-2 min sensory break. Student volunteers lead any needed break activities, which included activities such as Simon Says and Follow the Direction. Participants were also used as indirect models for targets by role-playing as a participant and for generalization activities in Spanish to a novel listener.

Parent involvement depended on the family and child. Most communication was made directly with the mothers of the study and for all families in Spanish. During treatment sessions, parents were typically present in the background doing household tasks but at times would listen in or watch sessions. Siblings at times would watch the sessions or participate indirectly during game activities as an extra player. This was done to increase engagement and increase familial involvement. Parents were kept apprised of progress, goals, and schedules at the end of each session. At the end of treatment, parents were given a summary of final assessment results.

2.7 Scoring

Probe data was recorded prior to treatment for each session using target words in Spanish and untreated exemplars in English (the language of generalization) in a randomized order. Due to the often unpredictable nature of the at-home environments, scores were confirmed via audio for any sessions in which hearing was a difficulty. Audio was recorded using an ARM-based, active noise cancelling MP3 Apple © microphone, capable of recording compressed audio, at 64 kbps and 48 kHz sampling frequency. Files were uploaded to a password-encrypted server.

Interobserver data was collected for 1/3 of the sessions and scored from audio recordings. Observers were native bilingual, undergraduate volunteers who had previous taken the department's Clinical Phonetics course. One volunteer attended the sessions for Participants 2 and 3. The second volunteer received audio training trials before scoring. Both volunteers were given operational definitions for each target (see Participant Profiles). Procedures were adapted from Kennedy (2005). Sessions for scoring were drawn using a random number generator. Raw data scores were extracted and uploaded into a unique spreadsheet for each scorer for blinding purposes. We used an exact-agreement approach in which responses for each observer were compared for agreement and given either a score of 1 (agreement) or 0 (disagreement). The percentage of agreements was then divided by 100. We chose this approach over total agreement (i.e. tallying total correct responses for each observer) due to the high level of sessions in which total accuracy would be 0% (e.g. baseline) to avoid 0 numerators or denominators (i.e. mathematical situations of 0/0). Overall interobserver reliability was 80% in English and 86% in

Spanish. This falls within the reported 80% benchmark of Kennedy (2005) for single-case designs. It is important to note that with exact-agreement criterion can be difficult to achieve (Kennedy, 2005), as it requires alignment of judgement for each word item versus overall score (i.e. 4/10 vs. 4/10). As such, these numbers may appear deflated. Nevertheless, we noted that our volunteer that scored Participant 4, who was prone to lateralization errors with /tʃ/, consistently gave higher scores than the author. Distortions may have been more challenging to identify and/or the term lateralization unclear to a novice scorer. High-frequency distortions are also inherently harder to score via audio format (Shriberg, et al., 2019).

Chapter 3: Participant Profiles

For our summary of participants, we focused on the quality indicators presented by Horner et al. (2005) for single-subject research designs, What Works Clearinghouse Procedures and Standards Handbook (2014), and the Council for Exceptional Children Standards for Evidence-Based Practices in Special Education (2014). We provide a description of participants by detailing not only speech profiles but additional language and exposure data for each participant along with stimulability data for each target goal. We also provide detailed operational definitions for each dependent variable (DV). In addition, we provide a detailed transcription of the therapeutic steps (IV) that were taken to manipulate this DV for purposes of replicability.

3.1 Participant 1

3.1.1 Overview of Participant 1

Participant 1 was age 6;1 at the time of testing. He was 6:5 when he started the training portion of the study due to scheduling conflicts (i.e. addition of new sister, a death in the family, and sickness). He was referred by the University of Texas Speech and Hearing Clinic. He was previously diagnosed with a mixed language and phonological delay. Speech goals at the time were focused on producing /l/ in all word positions. Participant 1 was also receiving speech services through his school. School goals included consonant blends and /d/ in all word positions (i.e. stop and spirant versions) in Spanish. Mother expressed concerns with his ability to speak clearly and communicate ideas in general.

Participant 1 lived at home with his two parents and younger sibling (see Participant 4). His father worked construction and mother was the homemaker. He was first exposed to English at the age of 3. Per parent report via the Bilingual Input Output Survey (BIOS), he received 65% of his input in Spanish (45% in English) and used Spanish 48% of the time expressively (52% in

English). He primarily communicated in English at school and with his little sister who was also reported to have a speech and language delay (see participant 4 profile). Participant 1 passed a hearing screening at 20 dB bilaterally and voice was not an area of concern at the time of testing. He was reported to have some mild disfluencies that were being monitored by his previous clinicians, though no disfluencies were noted during the initial assessment. Later, in therapy, he was noted to make occasional repetitions without any secondary behaviors in conversational speech.

In the area of language, Participant 1 had a standard score of 78 in Spanish morphosyntax and 103 in Spanish semantics as measured by the BESA. His English scores were considerably lower with a standard score of 50 in morphosyntax and semantics respectively. In a narrative (tell) task using the books "Frog where are you?" in English and "Frog goes to dinner." in Spanish, Participant 1 made frequent errors with pronouns, articles, and prepositions and phrases were at times telegraphic in nature (e.g. y *niño y rana dicieron adios*/boy and frog said* bye). Mean length of utterance in words was 6.4, though his longest utterance was 10 words long. In English, mean length of utterance in words was 3.3 and phrases consisted of subject + verb root + object or adjective (e.g. Dog look at bees). He frequently repeated ideas and at times said "I don't know" for vocabulary. His longest utterance was six words long.

In the area of speech, Participant 1 was administered the BESA phonology subtests and CPAC-S. He scored a standard score of 56 (<1st percentile) on the English Phonology subtest and a standard score of <55 (<1% percentile) on the CPAC-S. In English, his whole-word productions were 19% correct (6/31) and total consonant correct production was 69% (67/97). In Spanish, his total words correct were 25/64 (39%) and percent consonants correct was 75% (134/179); he fell below the 1st percentile. Frequent patterns of error included /r/ deviations (lateralizations) & deletions both in singleton and in clusters in Spanish and English, partial stopping of /s/ across languages (e.g. [ᵗs]) and distortions, stopping of Spanish spirants /ɣ/, /β/, and /ð/, bilabial production of /f/ in Spanish and English, and errors on multisyllabic words (e.g. weak syllable deletion, consonant omission). Participant 1 was partially stimulable with a model and cues for blends at the sound level but not /s/ at the time of assessment. The process of cluster deletion impacted intelligibility the most on conversational speech. See Table 6 for a summary of these results.

3.1.2 Treatment

Treatment focused on production of /r/ blends. This goal was chosen because it impacted intelligibility to a high degree and was consistent with his school-based, individualized education plan. /r/ alone was not chosen as a goal since it did not overlap significantly in phonetic features. /ɹ/ in English is [+] alveolar, [+] voiced but [-] trill (i.e. [+] rhotic) whereas /r/ in Spanish is [+] alveolar, [+] voiced and [-] trill (i.e. [-] rhotic). /r/ plus a consonant cluster included the phonetic features of the additional consonant that did share phonetic features (e.g. /k/ in /kr/). In addition, the CCV syllabic shape is one that overlaps across Spanish and English. /s/ was excluded since he was not stimulable for that sound at the time and it was a mild deviation not impacting communication significantly. Multisyllabic words were considered initially but blends chosen over that goal since at that time he was part of an experimental design that was across participants and not behaviors (i.e. with only one goals being selected) and his performance on multisyllabic words did not stand out above cluster reduction. Finally, based on language sample, no /r/ blends were being produced in conversational speech. Stimulability testing indicated that Participant 1 was stimulable for all combinations of consonantal blends but the least stimulable for velar blends. Those results are presented in Table 7.

3.1.3 Target Stimuli

Initial velar blends were chosen as the stimuli for targets 1 and 2. These words were chosen from Dílo Así © in Spanish and Super Duper Photo Phonology © in English. The addition of both /kr/ and /gr/ blends was made to include additional items for future analysis. These stimuli are presented in Appendix 2.

3.1.4 Treatment Strategies

Treatment of blends consisted of modeling the target phoneme and contrasting it with the errored phoneme (e.g. /krin/ vs /klin/ or /kin/) in addition to articulatory clues. As Participant 1 had a strong ability to decode words, the graphemes were included with the target stimuli and the target phoneme was also underlined to highlight the focus of the treatment. Feedback was given for accurate and inaccurate productions as previously described. Graphemes were not included and unknown words were elicited through imitation. Each session included 75 – 100 trials. As there was no second target behavior, there was no reduction in number of trials during the treatment phase.

3.1.5 Scoring and Operational Definition

For target 1, initial target behavior consisted of marking the /r/ consonant with either a trill /r/ or rhotic. Due to inconsistency in scoring amongst observers, for reliability scoring it was later added that this sound must be in sequence with the previous consonant (e.g. /grado/ = 1, /gərado/ = 0). Any ambiguity in lateralization was considered a 0 (incorrect).

3.2 Participant 2

3.2.1 Overview of Participant 2

Participant 2 was age 6;5 at the time of testing. She was referred to the study by her school SLP. Her school reported speech and language goals with speech goals focusing on producing multisyllabic words and also producing “a variety of consonants” at the word level. She was receiving 30 minutes of weekly therapy at her home school but not enrolled in other special education services. Her mother expressed concerns regarding her speech and language skills in general.

Participant 2 was born in Mexico and came to the United States at the age of 5, the time at which she was also first exposed to English. She had an older brother that was reported to be typically developing. At home, Spanish was the primary language of use, though she communicated with her brother in both Spanish and English. Her mother worked in the school kitchen at her local school and at a hair salon as a second job; her father worked in construction but did not live with the family. Per parent report, Participant 2 received approximately 83% input in Spanish (17% in English) and her output was approximately 85% in Spanish (15% in English), though this may have under estimated her exposure to English, as her school day was reported by mother and not her teacher. She passed a hearing screening in both ears and fluency and voice were not areas of concern.

In the area of language, Participant 2 tested below normal limits on the BESA morphosyntax subtests in both English and Spanish with a standard score of 60 and 60 respectively. She tested within normal limits in semantics in Spanish as measured by the BESA with a score of 93, though frequent difficulties with word-retrieval were later noted in therapy sessions. In a narrative (tell) task using the books “Frog where are you?” in English and “Frog goes to dinner.” in Spanish, Participant 2 presented with frequent morphosyntactic errors. At times, Participant 2 used gestures to communicate ideas in Spanish (e.g. el sapo se hizo así), and more frequently used rote phrases to communicate ideas (e.g. *la mamá está enojada*/mom was mad, *el papá está enojada*/dad was mad, *la niña está enojada*/[the] girl was mad), with agreement errors, and a mean length of utterance in words (MLUw) of 4.5. In English, her MLUw was 3.1 and sentences were typically in the form of subject + verb + object (e.g. boy is mad, frog is gone, boy is under) that she repeated across pictures in a similar manner. She would also gesture to communicate ideas or switch to Spanish if she knew the word utilizing her bilingual skills as needed.

In the area of speech, Participant 2 scored below the 1st percentile on the English Phonology portion with a standard score of 56 and at the 2nd percentile on the CPAC-Spanish with a standard score of 71. Total words correct in English were 10/31 (32%) and total consonants correct were 77/97 (79%) on the BESA. Whole words correct were 46/64 (72%) and percent consonants correct was 88% (158/179) as measured by the CPAC. Single word articulation testing indicated errors with /r/ in both languages resulting primarily in lateralization (/bra.so/ → [bla.so], /bridge/ → [blidge]) or deletion (/kre.ma/ → [ke.ma], /əm.brɛ.lə/ → [əm.bɛ.lə]), stopping of spirants in Spanish (/glo.βo/ → [glo.bo], /de.ðo/ → [de.do]), cluster reduction, and final consonant deletion. However, what characterized her speech primarily were inconsistent production of these sounds in multisyllabic words (e.g. /la.li.pap/ → [e.li.pat]) with errors increasing with the length of the word. Production improved with imitation and she presented with no signs of groping. These results are presented in Table 8.

Follow up testing using a variation of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Crosbie, Zhu, Holm, & Ozanne, 2002) with multisyllabic *cognates* (i.e. repeated probes three times in each language spaced by an activity in between) indicated Participant 2 was 60% consistent with her speech production (15/25 in English, and 15/25 in Spanish) of multisyllabic words across languages that ranged from a level of 4 – 9 in phonological overlap (Kohnert et al., 2004) with a mean average of 7.4. Examples of errors included: [peli], [pe.li.ka.no], [me.li.ka.no] in Spanish and [pɛ.lɪ.kɪn], [pɛ.kɪn], [pɛ.lɪ.tɪn] in English.

3.2.2 Treatment

60% accuracy was higher than the 40% cut off used by Holm and Dodd (2001) for a diagnoses of an inconsistent speech disorder but multisyllabic targets were chosen based on communicative difficulties observed and reported by both parent and school with multisyllabic words. In addition, choosing a single focused target was challenging due to the variability in production. However, instead of focusing purely on consistency, the focus was shifted to accuracy as well since performance was higher. Baseline probes were taken at the beginning of each session. Baseline and treatment accuracy was scored out of the five treatment words (i.e. score / 5) per set.

Target syllabic shapes were chosen based on level of phonological overlap. According the Markedness Differential Hypothesis (MHD) (Eckman, 1977), errors are more likely to occur in areas where the phonotactics of two languages share the least phonological similarities. As such, set one targets overlapped in phonetic features considerably and syllabic shapes were chosen that were primarily simple, CVs syllables. This was chosen to establish the behavior and provide a base for future scaffolding. Set two targets added the addition of a CVC syllable words in word-final position. Set three targets included clusters. The motivation for choosing each set of targets was to facilitate overall motor programming but focus on those areas that were produced inconsistently more than 50% percent of the time. It's important to note, that although orthography may overlap (e.g. general vs. general), phonemes do not (e.g., /he.ne.ɾal/ /d͡ʒɛ.nɚ.ɹəl/). Words were chosen based on phonemes and scored for phonological overlap based on the work of Kohnert et al., 2004. Treatment shifted to the next set once trained word accuracy had reached 80% accuracy in each of two consecutive sessions on treatment words, 3 replications of the effect in the behavior, and a stable baseline had been achieved for the upcoming set.

3.2.3 Treatment Stimuli

Treatment words were chosen from the larger set of 25 multisyllabic words that were primarily in CV syllable shapes, produced differently at least 1 out of 3 times across languages, and in error at least 2 out of 3 times. Based on this criteria, 5 words remained. Two out of five words were novel to the child in Spanish (*mandarina, pelicano*) and 3 were not (*cocodrilo, banana, gorila*) based on receptive identification across languages in set 1. *Cocodrilo* was included even though it was of higher phonological complexity, as it was one of the few words the participant labeled independently. The mean level of phonological overlap for set 1 was 7.4 for the selected items. Items for set 1 and all sets are listed in Appendix 3.

Words for treatment sets 2 and 3 were comprised of three-, four-syllable and five-syllable words and drawn from a separate set of 15 words using the same error criteria and process as set 1. Set 2 words chosen because they all had final consonants, which was identified as consistent source of production difficulties for her. One word (*hipopótamo*) was included because it had 5 syllables but no final consonants or clusters to create a transition between sets 2 and 3 and because the participant labeled this word independently as well. It was included as a "challenge" word. Three words were discarded for treatment based on high performance during baseline: *cafetería*, *compañía* (produced with /n/ and deemed acceptable as judged by heritage speaker volunteers), and *actividades*. 3 out of 5 words were identified receptively (hipopótamo, television, general) and 2 were novel (*horizontal, diagonal*) in Spanish based on receptive identification across languages. Baseline began at the onset of treatment of set 1. It was not started earlier, as it was not part of the original design for this participant. Average level of phonological overlap for set 2 was 6.4.

The remaining 7 words comprised set 3. Average level of phonological overlap for the set 3 was 7.6. Although the level of phonological overlap was higher for set three stimuli, these words were phonologically more complex. Set three was chosen to include both word-internal clusters and word-final consonants in multisyllabic words. The additional of clusters and word-final consonants was based on error patterns that were exhibited during testing and early treatment sessions and included to scaffold the level of challenge of difficulty (i.e. set 1 < set 2 < set 3). Baseline began at the onset of set 1. Two words (multiple and invisible) were discarded based on high performance during baseline. *Construcción* and *explosión* were words identified receptively.

3.2.4 Treatment Strategies

Therapeutic strategies included counting syllables on the hand and matching the number produced by the clinician. Treatment hierarchy followed the following protocol, which was based on a variation of Core Vocabulary (Holm & Dodd, 2001) and motor programming principles (Edeal & Gildersleeve-Neumann, 2011; Skelton, 2004) specific to the participant:

- Contextual learning (i.e. This is a picture of a pelican. A pelican is a bird that stores fish in its mouth). Let's make the movement of a pelican (flap wings).
- Imitation with slow speech (/pe-li-ka-no/) in both forward and reverse directions (e.g. /no/, /ka-no/, /pe-li-ka-no/)
- Imitation with a normal rate (e.g. /pelikano/)
- Imitation with a pause (e.g. I'll say it, then you say it when I say go)
- Imitation with a motor movement (e.g. make a flat line (i.e. horizontal)

- Independent production in slow speech (e.g. Say it 5 times for me slowly)
- Independent production at a normal rate (e.g. Say it 5 times a little faster)
- Independent production at a rapid rate (e.g. Say it 5 times even faster)
- On-demand (picture stimuli presentation) contrasting production at normal rate (e.g. diagonal, horizontal, diagonal, diagonal, horizontal)

This protocol was repeated for each treatment set. 75 – 100 target trials were made for each set during its first treatment phase. As treatment shifted to the next phase, practice was discontinued (maintenance phase). During the second treatment phase, productions ranged between 10 – 20 trials due to time constraints on the sessions (i.e. targeting 3 goals simultaneously at 50 productions each was not feasible).

3.2.5 Scoring and Operational Definitions

Words were scored based on syllables and phonemes correct. Developmental errors (e.g. [w] for /r/) were accepted along with substitutions if they included transferred phonemes either vocalic or consonantal in nature (e.g. [ɹ] for /r/). Deletions of any form were considered incorrect (0). Productions were confirmed by audio playback. Ambiguous productions were scored as incorrect.

3.3 Participant 3

3.3.1 Overview of Participant 3

Participant 3 was age 5;0 at the time of testing and referred by her family to the study. She was not enrolled in services and had no previous diagnoses. Participant 3 was born in the U.S. and was exposed to English and Spanish since birth. Her mother was the homemaker and father worked in construction. She had an older sibling that was reported to receive speech and language services through the school district. Per parent report (Bilingual Input Output Survey), she used and heard Spanish 76% of the time and English 24% conversely. She interacted in English primarily at school and with her older brother, and in Spanish at other times. Parents' main concerns were that her peers, teachers and unfamiliar people could not understand her speech. She began Headstart at age 3. Participant 3 passed a hearing screening at 20 dB in both ears and voice and fluency were not areas of concern at the time of testing. Unlike the other participants, there was no previous history of diagnosis of a speech or language delay for Participant 3.

In the area of language, Participant 3 was administered the BESA and scored low average in the area of semantics (standard score of 78) in Spanish. Her corresponding score in English was 62. Her best morphosyntax score was 75 in Spanish with a corresponding score of 58 in English. A language tell was completed using "Frog where are you?" in English and "Frog goes to dinner" in Spanish. In Spanish, phrases were telegraphic in nature at times and included frequent omissions of prepositions and article errors (e.g. *la rana estaba señor cabeza/*the frog was man head). Mean length of utterances in words (MLUw) was 4.86. In English, phrases consisted of single word utterances.

In the area of speech, Participant 3 scored below normal limits across languages with a standard score of 75 (5th percentile) in English and 65 (1st percentile) in Spanish as measured by the BESA phonology subtests. She presented with the phonological processes of stopping fricatives (e.g. /s/ → [t], /z/ → [d], /f/ → [p]), cluster reduction (e.g. /bl/ → [b]), and tap/trill & /r/ deviations (e.g. /r/ → [d], [l]) across languages. Parents reported this to be consistent with what they heard at home in conversational speech. Whole-word productions were 29% accurate (8/28) in Spanish with 73% consonants correct (68/93). In English, whole-word productions were 39% accurate (12/31) with 80% consonants correct (78/97). This higher performance in English may have been due to the fact she knew fewer words in English and produced more words with imitation. She was stimulable in isolation with a model and visual cues for /s/ and stimulable at the syllabic-level for bilabial /l/ clusters. She was not stimulable for /f/. See Tables 9 and 10 for a summary of testing and stimulability results.

3.3.2 Treatment

Two processes were targeted for intervention based on assessment results: stopping and cluster reduction. These processes were chosen as the they were the most frequently occurring patterns in her speech affecting intelligibility and fell within developmental age range for production. Initial and medial /s/ words were chosen as target 1 and /l/ clusters as target 2. /l/ clusters was later shifted as target 3 and second set of final /s/ words was chosen for target 2 (see below). /s/ was chosen since it is a fricative sound that can occur in initial-, medial-, and word-final position in both languages. Target 1 words included initial and medial /s/ sounds. Target 3 words included clusters in word-initial position. /l/ clusters overlap in both Spanish and English in word-initial position. We chose to treat stopping before cluster reduction since it was the least stimulable sound and less likely to spontaneously recover based on lower levels of stimulability accuracy.

3.3.3 Treatment Stimuli

Target one stimuli (stopping) was chosen based on materials familiar and accessible to practicing bilingual clinicians. Target two stimuli was developed in the course of training target one, which did not respond to initial introduction of therapy. Participant 2 demonstrated accurate production of /s/ in final position with a model during trial sessions during the course of treatment for target 1. Demonstration of stimulability was a preferred for this study based on previous research demonstrating growth for stimulable targets within a shorter treatment range (Rvachew & Nowak, 2001). These items were chosen and probed in her home utilizing household objects. This was done in hopes that being able to independently name treatment targets might aid in acquisition of skills and generalization activities. As a consequence, they were all items she could name independently in Spanish. This differed from stimuli selected for other participants. English targets were chosen based on picture stimuli from Super Duper ©, as naming independently was not possible based on her English language skills.

Target 3 stimuli were chosen to reflect stimuli that would be familiar and accessible to bilingual practicing clinicians as well. 10 items were selected in both Spanish and English. The original stimuli paired the target (e.g. *playa*) with the later developing sound (e.g. *laya*). Unfortunately, these minimal pairs used in the stimuli did not match her pattern of errors in which the second (i.e. later developing sound) was deleted (e.g. [*paya*]) (see also stimuli for participant 4). As such, new treatment (but not new probe) stimuli were created. For words in which an errored pattern did not result in a real word (i.e. a nonce word was the production), a "silly" cards were used in its place. For example, for *globo*, a picture of a balloon was on the target (and probe) word card; however, for *gobo**, a silly face was used. Silly words served as contrasting nonword pairs. Nonwords have been effectively used in treating speech sound disorders in monolingual children (Geirut & Morisette, 2010), although not in this manner. These words are presented in Appendix 4.

3.3.4 Treatment Strategies

Treatment strategies included both phonological and articulatory approaches for target 1, articulatory approaches for target 2, and primarily phonological for target 3. Therapy protocol began with teaching the /s/ sound in Spanish and practicing production with a model and a "smile" as some mild distortions emerged with repetitive practice in isolation. Once the target sound was taught (first session), the second session transitioned to identification of the /s/ vs. the /t/ sound using minimal pair cards along with receptive practice. Productions moved to attempting to establish the sound in syllables with a pause (e.g. /s/…. /a/, /a/…. /s/…./a/) and then shortening the length of that pause (/s/../a/, /a/../s/../a/). Treatment was further combined with minimal pair cards matching the productions to the target (e.g. /s…arta/) and the errored sound (e.g. /tarta/). It was noted at this point that ingressive productions were emerging. As this did not result in accurate target productions, the next therapeutic approach involved tactile tracing of the /s/ sounds along the shape of a gusano (*worm*) (she was scared of snakes, a typical association used in intervention for /s/) followed by a line to the initial-/s/ word and no line to the initial-/t/ word. She was told the *gusano* only liked to eat words that starting with /s/ and needed help.

Final /s/ was targeted through an articulatory approach, as previous phonological work demonstrated she had the phonological awareness already established as a foundation but was making atypical fricative productions. Participant three was partially stimulable for final /s/ (See Table 10). Therapy focused initially on inhalation and blowing out with a piece of paper used as feedback, as she tended to make an ingressive fricative production for /s/. Once eggressive airflow was established, she was prompted to smile and bite to make a "strong" /s/ sound for non-distorted, eggressive fricative productions. Once this had been established, target words were practiced in unison, with a delayed model, with a direct model, with a prompt, with a novel listener (i.e. volunteer, parent), and then trials to remember on her own without a prompt. To train this, we taught her that her new goal was to remember on her own and randomly presented the treatment cards throughout the session. We gave stickers for every time a card was presented and she remembered without a reminder.

The /l/ blends were taught through use of minimal pairs and articulatory cueing. Approximations were reinforced with verbal praise behaviorally to shaped target production. Errored words were paired with target words, syllables and pictures. Participant 3 was directed to produce the errored sound followed by the target word. If a cluster was reduced entirely, the participant was redirected to the errored sound and the target sounds (e.g. I heard *pato* (points to duck). Let's say *plato* (points to plate)). Since participant three could accurately make /l/ in isolation and in clusters with a visual cue, words were also practiced in isolation through rote drill after minimal pair work.

Fifty trials were made per target during the treatment phase. As treatment shifted to final /s/ targets, treatment was given intermittently for initial and medial /s/ targets. As treatment shifted to clusters, 10 – 20 trials were given to final /s/ targets. Reduction of trials for initial and medial /s/ was due to poor response to therapy and time constraints (i.e. targeting 3 goals simultaneously at 50 productions each was not feasible).

3.3.5 Scoring and Operational Definitions

The /s/ productions were scored as accurate if production of the sound was fricative, voiceless, and either alveolar or interdental in nature. Interdental productions were produced as she began to learn the sound and these were accepted since they were within developmental range and the overall goal was to reduce the process of stopping and produce egressive fricative productions. Reinforcement was given for the "airy" portion of the production but credit was only given for complete fricative sounds. Ambiguous productions were scored as incorrect. Interdental productions were most common on trials she independently produced without a reminder across goals.

The /l/ clusters were scored as accurate if they included production of two sounds in adjacent consonant positions followed by a vowel when given a model without any rhotic quality. Approximations or gliding (e.g. /j/, /w/) substitutions in lieu of /l/ were scored as correct (e.g. [pw]). These criteria chosen since the target phonological skill was ultimately to mark two sounds in the onset position of the syllable and give credit for improvement of reducing the cluster entirely. Rhotics were scored as incorrect since these represented a deviation from developmental trajectory. Deletions were scored as 0. Again, ambiguous productions were scored as incorrect.

3.4 Participant 4

3.4.1 Overview of Participant 4

Participant 4 was originally referred at the start of the study by her mother but not initially enrolled. She was the sibling of Participant 1. Parent reported concerns with pronouncing words and expressing ideas. She was reportedly receiving services through her school for a mixed, expressive-receptive language delay and had been receiving services via the University clinic over the last year for speech and language. At that time, she was age 4;9. She presented with a significant phonological delay as measured by the BESA with a standard score of 60 in Spanish. Whole-word productions were 11% accurate (3/28). Her MLUw was 1.8 in Spanish. Importantly, she was unable to imitate words in English. No further testing was completed, as she did not meet the requirements for the study at the time which required ability to imitate target words in English.

She was reevaluated 6 months later again with the BESA phonology subtests. She was age 5;3 at the time of testing. Per parent report, she had been enrolled in a dual-language kindergarten and her English output at the time of second testing was 47% as measured by the

BIOS (Spanish output 53%). She received 31% of her input in English and 69% in Spanish. She continued to score below normal limits in the area of speech with a standard score of 65 (1st percentile) in Spanish and 60 in English (<1st percentile). Whole-word productions were 29% correct (8/28) and total consonants correct was 77% (71/93) in Spanish. In English, whole-word productions were 26% correct and 76% of her total consonants were correct (74/97). It's important to note that the vast number of these production were produced via imitation; however, importantly, she was now able to imitate words in English. She presented with frequent reduction of clusters across languages, deletions and substitutions of /r/ (IPA), and distortions (lateralization) of /tʃ/.

Follow up assessment in the area of language was completed using standardized testing and the stories "Frog where are you?" in English and "Frog goes to dinner" in Spanish. The BESA morphosyntax and semantics portions were administered and she scored a standard score of 62 and 93 respectively in Spanish. She did not give any answers in English for the morphosyntax portion and her scores in Spanish were deemed to be most reflective of her abilities. For the narrative portions, her MLUw was 2.5 and her longest utterance was 4 words long in Spanish. Utterances consisted of phrases with content words and few articles or clitics (e.g. *se fue su cuarto*/ [he] went his room; *agarró*/ [he] grabbed). In English, she repetitively said "I don't know," gestured or gave single word answers. See Table 11 for summary of results.

The family of Participant 4 (and 2) left to visit relatives in Mexico toward the latter portion of the study. As such, telepractice was used for the remaining treatment sessions and for the post-test assessment. We wanted to attempt to reach criterion levels for all behaviors. A video connection was established via Zoom © with the family before leaving to Mexico. Rewards for working were given in advance to the family. We checked to make sure the family had wifi and that there would be a quiet setting with lighting before transitioning treatment to this mode. The participant had previously presented with the ability to attend to a screen and manipulate a portable device. Parent reported no concerns with vision and she did not wear glasses.

Treatment sessions followed a similar designed as previous sessions. A reminder was sent to the family the day before to confirm attendance. Parents were available and present in the background for assistance during sessions if needed. A visual schedule was provided to the child via powerpoint. Stimuli were presented on pdfs and flashcards. Articulatory practiced was given in blocked trials. Interactive games and books were used as reinforcement and break activities via screen sharing. We gave practice trials in blocks to ease the transition of screen sharing. During trial work, video was shared so that both view of the clinician's and child's mouth were visible. The author used an iMac retina 5k with a 27" monitor and the family of Participant 4 used an iPhone 8plus. Sessions were reduced to 30 minutes to accommodate attention abilities, as managing behavior was less feasible remotely. Treatment for target 1 was discontinued since Participant 1 had reached criterion levels during treatment tasks independently with a prompt, near criterion levels without a prompt, and for efficiency of telepractice sessions. Probe portions of the session were video recorded.

3.4.2 Treatment

Two processes were chosen for treatment: cluster reduction and lateralization of affricates. These processes were chosen as they were the ones most frequent in her speech that also included sounds that overlapped phonetically between Spanish and English. /r/ deviations and deletions were not chosen since the level of phonetic overlap alone was likely to be insufficient (see previous). Again, /l/ clusters were chosen since they were one of the few overlapping cluster combinations across languages and /tʃ/ since it is the only overlapping affricate phonemically. Participant 4 was not stimulable for either target (See Table 12). We chose to treat cluster reduction before lateralization since it was the target most likely to result in treatment growth based on informal observation and clinical judgement and impacting speech intelligibility to a higher degree (deletions > distortions).

3.4.3 Target Stimuli

Target stimuli was based upon Super Duper© Minimal Pair Cards in Spanish. The original stimuli paired the target (e.g. *playa*) with the later developing sound (e.g. *laya*). Unfortunately, these minimal pairs used in the stimuli did not match her pattern of errors in which the second (i.e. later developing sound) was deleted (e.g. [paya]) upon implementation during initial treatment sessions. As such, new treatment (but not new probe) stimuli were created. For words in which an errored pattern did not result in a real word, a nonce word was and a "silly" card were used in its place. For example, for *globo*, a picture of a balloon was on the target (and probe) word card; however, for *gobo**, a silly face was used. These words are listed in Appendix 5.

Target 2 stimuli were chosen to correct the lateral production of /tʃ/ and were targeted in initial-word position (overlapping structure). These words were drawn for CASA-Artic ©, and Articulation Station ©, both publicly obtainable applications. We paired these words with pictures from LessonPix ©. These words are presented in Appendix 5.

3.4.4 Treatment Strategies

Treatment strategies for target 1 focused first on identification of target cluster versus errored patterns. As the original stimuli did not include the errored patterns, the first sessions presented with variable data indicating lack of conceptual awareness. Again, identification was the first step and performance was markedly initially higher. Articulatory tasks were included since she was not stimulable for /l/ in clusters with a model but could, however, produce /l/ and the initial consonant in isolation accurately. Therapy activities primarily included matching and requesting minimal pair cards by both her and the clinician. Productions emerged as glides initially and these were reinforced during activities. If a cluster was reduced entirely, the participant was redirected to the errored sound and the target sounds (e.g. I heard *pato* (points to duck). Let's say *plato* (points to plate)). After minimal pair practice, target words were practiced once in isolation in a rote drill fashion (e.g. say *plato, playa, plazo*…).

Treatment strategies for target 2 included practicing blowing air out of the mouth to begin with to establish correct pattern of airflow. This was done using a piece of paper and instructing the child to blow air to "make the paper move." This was then transitioned to making the piece of paper move while producing the target sound with a model in isolation for /tʃu/. Syllabic targets began with back vowels since these are more rounded in both Spanish and English and helped to decrease the retracted lip position produced with her lateralized productions. Therapy shifted to all vowel forms with a cue to keep her lips in either a neutral or rounded position and continue to make the piece of paper move. From this point, vowel forms were shifted to target words that began with back vowels (e.g. *chorizo*) and then practice with all vowels. Upon reaching the linguistic level of target words, trials of previous linguistic levels were included (i.e. isolation, back syllables, all syllables, words with subsequent back vowels, all words). A piece of paper was used a visual reinforcement throughout all linguistic levels until accuracy on treatment trials reached 7/10.

Unfortunately, as described earlier, the family of Participant 4 needed to leave to Mexico before treatment of target 2 had been completed. The remaining 4 sessions were completed via

Zoom © using a portable device by the family and the author's desktop computer. Therapy activities continued in a similar manner but were conducted via this mode to end her treatment.

3.4.5 Scoring and Operational Definitions

Blend productions were scored on accuracy of production of a two sounds in adjacent consonants positions followed by a vowel when given a model. Specifically, approximations or gliding (e.g. /j/, /w/) substitutions in lieu of /l/ were scored as correct (e.g. [pw]). These criteria were chosen since the target phonological skill was ultimately to mark both sounds in the onset position of the syllable and reward for improvement of reducing the cluster entirely.

Target 2 was chosen to correct a lateral production of the voiceless palatal affricate "ch." Accurate productions were those that were voiceless, palatal affricates that included airflow in a forward direction out of her mouth. Deletions or lateralizations were scored as incorrect.

Chapter 4: Results

As previously described, to assess our results we graphed our data across behaviors for each phase and used visual analysis guidelines presented by Horner et al., (2005), Cook et al., (2014), and Clearinghouse (2014)., which included the following areas:

- analyses of mean levels of performance
- immediacy of effect following introduction or withdrawal of the independent variable
- trends (i.e. rate of increase or decrease of dependent variable)
- magnitude of changes.
- consistency of patterns (i.e. degree of fluctuation) within and across phases
- proportion of data in adjacent phases that overlap

Use of visual analysis is used to determine experimental control of the dependent variable, in this case accuracy of performance. We desire low levels of accuracy during baseline (for behaviors that are not trained we might expect these to be around 0%), higher levels during treatment (that ultimately reach 80%), a short immediacy of an effect upon introducing treatment, a rising slope as a behavior is learned, and low fluctuations within phases. The degree to which we see these is indicative of the level of experimental control. In addition, we seek growth that does not overlap across phases but instead is seen during treatment for only the behavior at hand. When we establish experimental control, we can feel confident it was our treatment that was responsible for the change.

Separate from the analysis, however, is the overriding clinical significance of the findings. To determine how effective our intervention was, we ultimately want to know if our intervention has made a meaningful difference for the participants in the area of speech and if this difference was seen across Spanish and English to answer our experimental question at hand.

To establish meaningfulness of significance, we used our previously established accuracy of 80% accuracy in each of 2 sessions. In addition, we asked if the effort to increase skills as measured in number of therapy sessions resulted in sufficient change to be worth the time and effort to produce the level of growth seen. We used 6-8 sessions for stimulable targets and 10 – 12 sessions for nonstimulable targets as our reference by when we would expect growth based on existing literature for monolingual children (Geirut, 2001; Rvachew & Nowak, 2001; Storkel, 2018). Gildersleeve-Neuman and Goldstein (2015) is our only reference for bilingual children. They report words being treated but levels of stimulability nor accuracy at the syllabic level is reported for comparison. However, growth was reported to be seen within a similar timeframe. Importantly, however, they included prompts for the children during their probe trials whereas we did not cue the children, an additional factor of difficulty that we took into consideration.

4.1 Participant 1 Results

Participant 1 was originally enrolled in the study in late September of 2018 and part of a broader study that sought 6 participants in a multiple-baseline-across-participant design. His data is included to show transparency in the data collection process. He was not transitioned to a multiple-baseline-across-behaviors design based on his point of state in the study. As such, his data is presented as a case study. Attendance for participant one was inconsistent and baseline sessions did not begin until December of 2018. At that time, baseline measures began for 3 sessions over one behavior (i.e. one behavior for each of 6 participants). He presented as 40% correct in syllables without a model for /r/ blends. Unfortunately, therapy was put on pause for 6 weeks, as the holidays and the addition of a new baby made scheduling difficult.

The next session occurred at the end of January 2019. Probe data indicated growth from the previous point in time so new baseline measures were again collected over a variety of behaviors since almost 5 months had passed since original testing. Again, however, therapy was put on pause as his family left to Mexico for a month due to a death in the family. At this time also, the design of the original study shifted, as recruiting families to participate in the study was proving more difficult than anticipated. When he returned at the end of March, the decision was made to initiate treatment with his goal despite less-than-ideal baseline stability, higher-than-ideal levels of accuracy, and limitations to experimental control to avoid further delays due to absences. Therapy began in early April. Participant 1 again missed several weeks of therapy due to cancelations and illness. After 3 treatment sessions, data levels indicated increased accuracy with target sounds compared to early baseline data that had reached criterion levels. Therapy was discontinued at this point.

A visual analysis of the performance of Participant 1 (Figure 1) shows 3 replications during baseline that are stable over the last two baseline points for Spanish /kr/. We see an overall rising trend across phases that begins to stabilize during sessions 6 - 7. We see a low rise in slope between sessions 1 -4 for all targets except /gr/ in Spanish. Upon initiating treatment, we see convergence of skills over the first data point at session 5 suggesting some stabilization of skills. The trajectory of /gr/ in English predicts treatment data points 6 and 7 but the drop in session 5 suggests this skill was stabilizing with the other targets as well. Since the data was collected over multiple months, it is difficult to judge the immediacy of an effect. We did not have a control variable to judge overlapping progress, either. However, the increase in slope (2 – 4 points) and stability seen over sessions 6 -7 are indicative of some small potential effects of treatment. This data suggests concurrent development across languages for /r/ blends but any results of progress due to treatment should be held with caution due to lack of complete experimental control. As such, we refrain from judging the significance of these findings beyond visual observation and trends.

Pre- and post-test data as measured by the BESA Phonology subtest in English and CPAC-S in Spanish indicate growth across languages in both consonant production and /r/ blends. This data reflects an interval of 9 months in duration. Overall growth across both languages is seen. These results are presented in Table 14.

4.2 Participant 2 Results

Participant 2 was initially part of a broader design incorporating 6 participants with only 1 targeted behavior that ultimately was transitioned to a smaller design for 3 with multiple targeted behaviors (i.e. current study). As such, baseline data for sets 2 and 3 reflect the later addition of these goals in a delayed-multiple baseline design.

Performance across languages was comparable during baseline conditions but rose quicker in Spanish than in English for all sets. Generalization results were seen for all 3 sets as well, though performance afterward was lower in English than in Spanish. In addition, these results did not maintain in the same fashion across languages. Upon reaching criterion for set 1, the focus of therapy shifted to set 2, and upon reaching criterion for set 2, the focus of therapy shifted to set 3. In each case, a drop in performance was seen in English but not in Spanish. As such, these words were reincorporated in the therapy activities, albeit to a lower degree, with approximately 20 productions for previously trained sets. Performance at that time rose again resulting in a second replication for each set. As mastery for all Spanish items had been achieved by set 3, there were not opportunities for an additional withdrawal. Participant 2 was reported to be sick with a fever the day before session 14, which may have resulted in lower than expected performance. In addition, Participant 2 needed to exit the study after treatment of set 3 visit to relatives in Mexico and continuing treatment was not an option based on familial circumstances. These results are presented in Figure 2.

A visual analysis of the data (Figure 2) indicate experimental control for all three targets. We see stable trends in baseline performance for sets 2 and 3 and set 1 in English over three data points. We see a slight rise from session 1 to session 2 in Spanish for Set 1 words (0 to 2 words). While lack of stability might possibly indicate skills were improving in Spanish, the immediacy of the effect within 1 treatment session, sharply increasing slope (rise from 2 to 4 words or 40% to 80% accuracy) and consistently stable performance at 5 words and 100% accuracy in Spanish upon administering intervention is highly suggestive that it was therapy that was responsible for the growth in skills and not outside variables. This pattern is more strongly presented in sets 2 and 3 and replicated in each. We see a similar immediacy of effect in English for generalization targets. Notably, English targets were less accurate than Spanish targets, however. At times when treatment was reduced for previously trained targets in sets 1 and 2, which functioned as a partial withdrawal phase, we saw a drop in performance from 4 to 2 words (80% to 40% accuracy) further suggesting it was our therapy that was responsible for the change. Finally, we see 3 successful replications across behaviors for sets 1 – 3 with performance on accuracy only increasing upon administering therapy. Together, these data show a high level of control over accuracy of productions and indicate it was targeting word forms with high phonological overlap that resulted in the increase in both Spanish and English word-level accuracies.

Clinically, our approach proved effective for sets 1 and 2 in Spanish. We saw treatment gains stabilize at criterion levels for sets 1 and 2 within 7 treatment sessions. While set 3 did not stabilize, we did see gains that reached criterion levels in Spanish for set 3 within 3 sessions of treatment. Accuracy of performance did not reach criterion levels in English for set 3 but did reach 80% accuracy across two sessions for sets 1 and 2 in English. The results presented were seen within 11 sessions representing 385 minutes of interventions, which is within an expected time frame for 3 goals of 5 words (total of 15 words) using a comparable ratio of 10 words per 8 sessions.

Pre- and post-test data indicate improvement in both Spanish and English in both accuracies of consonant productions and multisyllabic words and are presented in Table 15. These data reflect a period of 7 months, 12 sessions and 420 minutes of therapy. Overall growth across both languages is seen.

4.3 Participant 3 Results

A stable baseline was established for behavior 1 within three sessions. Unfortunately, we did not see progress after 8 sessions and 1 month of treatment. Progress had not been seen at either the syllabic or word level for target 1, though identification of /s/ versus /t/ in treatment words was 100% and errored productions had begun to shift to [st] versus [t]. /s/ paired with vowels resulted in ingressive productions of the target sound. At this point, it was determined that participant 3 had developed some stimulability, however, for /s/ in word-final position and a 2nd baseline was established while treatment continued. Some small emergence of accurate production was seen beginning at session 12 (1 to 2 accurate fricative interdental productions) but still no significantly noticeable progress.

After a stable baseline during sessions 13 – 15 and continued lack of growth for target 1, treatment shifted to work on final /s/ (target 2). We saw probe data performance rise after 3 treatment sessions and continue to increase. Treatment data showed higher performance with a prompt to use her new sounds (80% - 100% accuracy). Generalization data followed a similar trajectory and the steep slope and immediacy of the effect upon introducing the independent variable strongly suggest this growth was a result of therapy. At a similar time, we began to see a slight rise in the performance for initial and medial /s/ targets. Productions were noted to be interdental in nature for both targets independently, consistent with typical developmental errors. Upon introduction of therapy for target 3, which coincided with a reduction in treatment trials, we noted a slight decrease in performance from 8 to 4 words further supporting treatment was the controlling variable.

Baseline trends for target 3 were initially stable but began to slight rise as treatment for target 1 extended beyond the anticipate 6-8 sessions and coincided with increased accuracy of target 2 (sessions 17 - 19). At session 20, when 3 increasing data points had been obtained for target 2 (final /s/), we saw an additional unexpected rise in the performance for target 3. Two additional data points were obtained (3 in total). This trend noted a rise followed by a decrease. We noted that this rise in performance was due to higher accuracy on /pl/ target stimuli with inconsistent accuracy for /fl/ clusters and poor accuracy for velar /kl/ and /gl/ clusters. Treatment was initiated at this point based on stability within the type of error productions and mean across sessions 20 - 22. We anticipated based on these data that accuracy of performance would respond quickly to treatment.

A visual analysis of the data (Figure 3) indicate experimental control for targets 2 and 3 but not target 1. We ultimately did not see growth beyond small fluctuations in the behavior of target 1 in either language. We did see growth at the level of recognition and generalization of skills seen from final /s/ targets in the similar manner, however (i.e. interdental fricative productions).

Upon introducing treatment for target 2, we saw an increase in behavior within 3 sessions in both Spanish and English. Based on treatment data, the variability in performance was based on lack of generalization to the non-therapeutic activity of probe data collection activities (no prompt to use skills), as performance had reach 80% - 100% accuracy on treatment trials consistently from session 8 forward.

Upon introducing treatment for target 3, we saw an increase in accuracy of performance from baseline. As baseline was already trending in an upward slope, we compared the rate of growth between both phases. We saw a slope of .5 for the last 3 data points before treatment and a slope of 3 for the initial 3 data points upon treatment in Spanish. The immediacy and magnitude of increase strongly suggest it was treatment that was the result of this growth. In addition, we noted that performance in Spanish stabilized at a score of 9 for the first time. Finally, we noted that other stopping errors presented in the treatment stimuli (e.g. /f/ → [p]) were emerging with increased accuracy (e.g. [flote] instead of [plote]) in Spanish. This further suggests the results were a direct effect of treatment.

Clinically, our minimal-pair approach did not prove effective for treating stopping for Participant 3 within 12 sessions but it did prove effect reaching criterion levels for /l/ blends in both languages within 5 sessions. In addition, we did see growth and have it reach criterion levels using an articulatory approach within 5 sessions for final /s/ in Spanish. We saw generalization of skills in English for final /s/ and for both English and Spanish for initial & medial /s/, with higher accuracy for final /s/. In summary, we saw significant results for targets 2 and 3 but not target 1 and within an expected time frame for final /s/ in Spanish and blends in both languages.

Post-test measures indicate growth across Spanish and English as measured by percent consonants correct and production accuracies for clusters on the BESA Phonology subtests.

These results reflect a span of 4 months, 22 sessions and 770 minutes of intervention. These results are presented in Table 16.

4.4 Participant 4 Results

Participant 4 was the last to officially enter the study. Her baseline data reflects performance immediately before treatment, not at her original screening. Baseline performance was stable for both target behaviors, although higher performance was noted in English. An additional data point was collected for Participant 4 and was a product of scheduling difficulties in which a full session was not able to be conducted during baseline. Both behaviors presented as stable; however, performance was higher in English for target 1.

A visual analysis of the data shows experimental control for both targets 1 and 2 (Figure 4). Introduction of therapy resulted in an initial increase in slope in performance in Spanish and in English. Within approximately 8 sessions, we noted a strong upward trend in performance in Spanish from 0% to 60% accuracy with a simultaneous increase in English from baseline levels of 3 words (30% accuracy) to 6 words (60% accuracy). Treatment data indicated at this time Participant 4 was marking /l/ with /w/ in her therapy productions. These emerged first with the bilabial targets /p/ and /b/ (similar to Participant 3). Performance in Spanish eventually reached performance in English and trends ultimately stabilized with comparable performance across languages in an upward fashion. The immediacy of the fact and stability of the trend are strongly indicative of the effects of therapy.

Introduction of therapy for target 2 was initiated once a stable upward slope was seen after the introduction of therapy for target 1. During this time, performance for target 2 remained stable during baseline probes. We saw an increase in performance from 0/10 words to 3/10 words across both languages upon administering treatment in Spanish. This was noted in combination with therapy data indicating increased accuracy in making forward airflow upon production and decreased lip retraction associated with lateralization. The family of Participant 4 left to Mexico for the summer before criterion had been reached. As such, we attempted to continue treatment via telepractice. We administered two sessions. However, audio quality was insufficient to hear the variation in higher frequency distortions in her speech during treatment activities to sufficiently reinforce and shape productions. As such, we discontinued therapy at this time. Despite the low level of gains seen, the rate of growth upon administering treatment (.75 words per session) is consistent with treatment being the primary variable responsible for her growth.

Clinically, our approach proved effective for both targets across languages. Before discontinuation of treatment, target 1 nearly reached criterion for accuracy in probe data in Spanish and did reach criterion for accuracy during treatment sessions within 17 sessions and 560 minutes of intervention. Importantly, this was done without a prompt for a nonstimulable target in Spanish and progress in accuracy was seen at a similar level of performance in English without intervention. Results for Target 2 are limited but indicate meaningful growth for a deviant production (lateralization) of a non-stimulable sound and are within an expected time frame. Importantly, growth was also seen at similar levels of accuracy in English. Those results were seen within 5 sessions and 175 minutes of intervention.

Post-test measures indicate growth across Spanish and English as measured by the BESA Phonology Subtest and accuracy of clusters and affricates. These results reflect a span of 4 months in duration, 17 sessions and 595 minutes of therapy. These results are presented in Table 17.

Chapter 5: Discussion

5.1 Overview

This study sought to facilitate cross-linguistic generalization of treatment goals from Spanish into English for children with speech sound disorders. It attempted to do so by utilizing the shared phonetic features of similar phonemes across languages to train skills in the children's dominant language. The hypothesis was that shared features would exhibit interactional effects and it was predicted that growth would be seen concurrently in Spanish and English when treating speech targets from phonological and articulatory approaches. The multiple-baseline-across-behaviors approach was utilized to maintain experimental control. Phonological and articulatory strategies were implemented in Spanish as the independent variable for four Spanish-English bilingual participants that were dominant in Spanish as measured by formal and informal testing. Accuracy of performance as measured by probe data in Spanish for treated words and in English for generalization words was the dependent variable. Importantly, targeted words overlapped in phonetic features and targets were controlled for phonological structure. Performance was compared across conditions to assess the effectiveness of treatment.

The results indicate that generalization of skills into English across languages is possible when treating sounds in the dominant language, in this case Spanish. All participants demonstrated cross-linguistic generalization from their L1 into their L2. In general, however, growth was lower in the L2 in comparison to growth in the treated L1. In addition, levels of accuracy of performance did not reach criterion for all behaviors in English. Nevertheless, all children demonstrated growth both in overall accuracy of consonant production and specific phonological patterns as measured by post-test results in both languages. Although 3 children were also receiving services concurrently through their school, our growth trends indicate that performance in general for our targets only rose upon the introduction of the independent variable. In addition, Participant 4 demonstrated a similar pattern and was not receiving outside services. These data strongly suggest the therapy of this study was the determining factor that contributed to their performance for the targets selected.

Our results show that bilingual gains can be facilitated through treatment in only one language. We want to be clear, however, that this does not indicate therapy in one language is sufficient to address all of the needs of bilingual children. The results show that therapy in Spanish not only does not result in decelerated growth in English but in fact can facilitate it. Spanish-speaking clinicians can administer therapy in Spanish and address goals in English as well. Importantly, we established these effects while reaching or nearly reaching 80% accuracy across multiple sessions for target behaviors in Spanish within 6 – 8 sessions at the word level with imitation but no prompts for the children to use correct sounds.

Unexpectedly, we observed a rise in performance for one target behavior (target 3, Participant 3) without the introduction of therapy directly to that target. Exposure to bilingual input alone (or maturation) may have be sufficient for some bilingual phonological development. Although the scores for Participant 3 remained relatively low before treatment, the slight upward trend was noted across languages. Repetitive exposure may aid development, in this case, in as little as 40 – 50 trials over the course of 2 – 3 weeks. Importantly, these were for sounds that were stimulable.

Additionally, performance in English may have been more sensitive to input than anticipated but only up to a certain threshold. Since the participants were not balanced bilinguals and presented with language delays, obtaining stimuli that could be named independently was difficult in Spanish and unobtainable in English. As such, performance was measured via imitation. Performance was higher on English generalization probes for two of our participants. Collecting data via imitation due to low vocabulary may have initially aided in English differentially over Spanish. Although phonological patterns across languages shared phonetic features, previous experience in Spanish may have resulted in more entrenched patterns. Nevertheless, this shift in trend changed once the targeted skill in Spanish began to emerge.

The level of stimulability likely influences how quickly change is seen. Participants 3 was not stimulable for target 1 in words or syllables and Participant 4 was not stimulable for target 2 in either as well. Growth did not occur in the same fashion as other behaviors within the expected 6 – 8 sessions (Rvachew & Nowak, 2001). However, they were stimulable for their other targets and responded quickly to traditional forms of treatment. These findings are consistent with previous finding indicating non-stimulable sounds are more resistant to change (Storkel, 2018). For cross-linguistic generalization, the results appear to show a similar pattern.

5.2 Discussion of Results for Individual Participants

It is likely that the progress in productions of /r/ blends for Participant 1 developed outside the confines of this study, though the practice and training received may have helped facilitate growth. Outside therapy and maturation may have been the strongest components. Nevertheless, the results from Participant 1 suggest acquisition of /r/ blends occurs concurrently across languages in Spanish-bilingual children. Although the experimental design was not strong enough to draw concrete conclusion, it suggests that the both English and Spanish /r/ productions transfer frequently across languages in developing bilinguals, as Spanish productions were observed in English.

For Participant 1, data suggest that transferring of skills might extend in ways not previously considered. Facilitation of cluster productions might be feasible for sounds that share less phonetic overlap, such as in /r/ clusters or /r/ alone. Differences in phonetic features may not need to overlap completely. In this case, targets shared the first consonant features and /r/ across languages shared the features of [+] alveolar, [+] voiced and [+] sonorant with the distinction being one of a division in manner (i.e. rhotic vs. trill).

The results from Participant 2 suggest cognates may be a viable form to facilitate generalization across languages. This study demonstrated cross-linguistic generalization with phonological targets that shared a high degree of phonetic overlap. Treatment took longer relative to the syllabic shape of the words. This was likely due to the participant's difficulties in general with final consonants and /r/.

The results from Participant 2 suggest maintenance of skills might require doses of therapy either in the language of treatment or language of generalization. Skills quickly diminished in English when the focus of treatment shifted to the next set of words but bounced back upon giving additional attention to previous stimuli. It is important to note that this child also frequently forgot and regressed in vocabulary naming skills both formally and informally as well during the course of the study. More general acquisition of learning might have been a factor. This is the first study to look at maintenance of skills in generalization tasks and it is unclear if results are unique to the participant or representative of more general difficulties with obtaining generalization of behaviors. English performance may also require higher levels of mastery in Spanish to stabilize.

The results from Participant 3 demonstrate acquisition of /s/ and consonant clusters can be facilitated across languages. It is important to note that progress of /s/ and production of clusters did not occur until final /s/ was targeted. It's difficult to know if this was due to overall maturation effects or shift in her system due to acquisition of new skills. Due to the fact that participant three was also noted to focus on the oral cues of the therapists at this time, it is suggestive of a shift in her phonological system and developmental skills. We did not anticipate targeting initial and medial /s/ would prove so challenging; however, in hindsight, choosing the most stimulable item to target first (even if performance is below 75%) would have protected against possible maturation effects as a result of an extended treatment phase for the first behavior.

It is likely Participant 3's delay in development was not purely phonological in nature but rather a combination of phonological and articulatory deficits. We observed productions of /s/ that were atypical in nature when they began to emerge, as she utilized an ingressive air pattern for the fricative sound, which is not developmental in English. In cases such as these, a combinatory approach may be necessary to facilitate growth even when phonological recognition is present or has been established.

The results from Participant 4 demonstrate cluster production for /l/ blends can be facilitated across languages. Importantly, no complete /l/ productions were produced on probe therapy but marking of the consonant with /w/ did occur. Interestingly, /pl/ clusters emerged first, which were also those more accurate in English. A similar pattern of bilabial production emerging first was noted with Participant 3.

Choosing the most stimulable behavior (i.e. cluster production) may have benefited our second treatment goal. While Participant 4 struggled with correct oral posture to produce /tʃ/ during the assessment phase, treating what was the least stimulable behavior second did result in gains. It's unclear if this progress would have been obtained if target 2 had been treated first, but this may be beneficial both in research and clinical strategies when appropriate.

Teletherapy ultimately did not prove to be a feasible modality for treatment of /tʃ/. We suspect this might be the case in general for high-frequency sounds at lower levels of connectivity. Nevertheless, teletherapy as a modality could have been an option for other goals. Participant 4 also presented with a language delay and had speech and language goals at her local school. The visual system, activities, and coordination of logistics with family all worked well to potentially continue services over her summer break despite being in Mexico.

Lower progress of /tʃ/ was likely due to lower stimulability, reduced time, and potentially mode of instruction. Lateralization is an atypical progress; as such, it is not one following typical developmental trajectories. In these cases, treatment progress may look different as well. Teletherapy may also not be best suited to treatment practices where tactile cues might be helpful or it may require alternate methods to achieve transfer of articulatory knowledge.

5.3 Limitations

Limitations to this study lie in external constraints, lack of experimental control for all targets, and less-than-ideal stimuli for some targets. First, inconsistency in attendance, environment and other conditions may have affected performance. Variability in performance, particularly for Participants 1 and 4, which were from the same family, could be attributed to attendance, multiple locations, and inconsistency in household conditions. The impact of working in new places, with different family members and multiple activities occurring in the background subjectively resulted in more challenging conditions both on the children and the therapist. As to be expected, there was some variability in performance and particularly so in these situations. Nevertheless, these also represent real-word conditions and it is possible training over multiple conditions may have resulted in better environmental generalization not represented in the data.

Second, lack of experimental control makes drawing any conclusions from the results difficult to do for Participant 1. It highlights the importance of clear behavioral definitions and the difficulty in doing so for approximant consonants that phonetically fall upon a spectrum of acceptable productions. In addition, not having two control behaviors makes conclusions suggestive but not definitive. Based on pretesting data, stimulability but not word-level performance shifted for other patterns of errors (e.g. /s/). As such, there is some data to support the notion the increases in performance for this behavior was not due to external stimuli and resulted in small gains.

Finally, original target stimuli likely led to some delay in progress. The original stopping stimuli contained only 3 initial-/s/ words which made the focus shift slightly to medial productions. In addition, the generalization stimuli contained a balanced ratio of 5:5 initial versus medial productions. This can give the impression of higher performance in one language over the other if performance is not equal for both sounds. In addition, her pattern of stopping (Participant 3) extended to other fricative sounds, such as /f/, which could potentially have been included in the stimuli. Finally, the original cluster reduction stimuli did not match the error pattern of either Participants 3 or 4 (although this was corrected before any treatment with Participant 4). Both of these situations highlight the importance of assessing off-the-shelf stimuli for clients. This study intentionally chose materials that were easily and widely available for clinicians and Super Duper © materials were pulled straight from the University Clinic. However, convenience can come at a price. We urge producers of materials to extend options and clinicians to carefully choose amongst them.

In addition, the nature of the stimuli model may have had an impact on performance. For the nature of this study, being bilingual has many advantages including allowing data collection by the principle therapist, interpreting code-switches, and in the ability to switch codes himself. However, bilingual productions of targets may be intermediate in nature. Flege (1987) demonstrated the merging of voice onset times of /t/ of French-English bilinguals that exhibited intermediate onset times across French and English. This theory also falls in line with later work demonstrating intermediate VOT during code-switch productions for bilinguals (Antoniou et al., 2011; Bullock et al., 2006; Piccinini & Arvaniti, 2014). That is, the productions of the author may already have shifted at the phonetic level. It is unclear at what level this may have affected generalization, but the possibility exists it may have facilitated interaction at some level. This is neither negative nor positive but rather a possibility to consider. From a clinical standpoint, however, modeling bilingual productions over monolingual productions gives the client a more natural model.

5.4 Significance and Implications

These findings support the interactional theory of phonological acquisition that treating the sounds in one language can affect the progress of similar sounds in the second language. The results also continue to support the notion that phonological systems across languages are interconnected. We saw this growth was variable in nature, as progress occurred for each child differently.

The significance of these findings are multiple. Clinically, this study extends the current line of research demonstrating how to address the needs of bilingual clients with speech sound disorders. Bilingual therapy need not always directly treat both languages for it to consider and address the needs in each even if directly treating both languages might be necessary in other situations or at a later time. The ramifications of this finding cannot be understated: monolingual clinicians can employ bilingual techniques to target the needs of a child in more than one language for speech sound disorders. In this study, we found that working in Spanish (L1) facilitates growth in English (L2) as well. Previous studies have attempted therapy only in one language (Holm & Dodd, 1997; Holm & Dodd, 1999; Ray, 2002); this study did so with a more rigorous experimental design. While their conclusions were suggestive of cross-linguistic generalization, this study provides additional evidence from a more experimentally controlled perspective, allowing for greater generalization.

Second, this study intentionally utilized materials and techniques that would be accessible not to just researchers but practicing clinicians as well. That is, our intent was that these finding be accessible both in content and practicality and have high ecological validity. Employing a multiple-baseline-across-behaviors approach is a technique that clinicians can do in their own practice to track treatment. Textbooks exist and programs often employ materials for Master's level clinicians in graduate school (for examples, see Hedge, 1998). The materials were ones easily accessible and the treatment techniques common but also thoroughly described. It is our intention that clinicians be able to employ the methods we used.

Disseminating treatment studies in our field with high ecological validity strengthens our foundation of knowledge of treatment principles. testing and using common materials, utilizing practical methods (i.e. mixed phonological and articulatory methods), typical clients (e.g. mixed delays) and treating in non-sterile environments is important not only to test our theories and techniques in different ways but also to close the gap off accessibility between researchers and practicing clinicians.

The participants in this study would not have been able to participate had services only been provided in person through the research lab, clinic or even their home. Lack of consistency of attendance, external distractions, and geographic and socioeconomic barriers can have a negative outcome on therapy. The nature of working with at-risk and disadvantaged populations can inherently impede the therapeutic process and this study highlights those challenges. All four participants were referred by other practicing bilinguals with whom they already had an established relationship of some form or another despite the fact that flyers were handed out to the majority of preschools, clinics and schools in the area to pass along to families. The family of Participants 1 and 4 frequently returned to Mexico for familial events. Participants 1, 2 and 4 all moved during the duration of the study and left to Mexico for the summer. The family of Participant 2 was a single-mother household in which mom worked two jobs. All of the sessions experienced some form of distraction during the session either from other family members or other activities occurring simultaneously, such as dinner being prepared while therapy was occurring, or even sessions where there was no table or chairs to work on. Maintaining interest and attention on the task was a constant challenge.

Nevertheless, this study demonstrates ways to navigate the inherent challenge of working with diverse populations. Increased flexibility both in schedule and location helped to support participants to remain in the study. We drove at times up to an hour one-way for each session, as the participants did not live in the center of town near the university. At times we even conducted therapy on the floor to accommodate familial circumstances. 3 out of the 4 families observed the sessions either directly or indirectly and the siblings of the participants were allowed to watch to increase engagement. Parents were included in goal making and updated on progress after each session. For Participant 4, the addition of telehealth sessions offers a particularly unique solution to this problem. We were fortunate that the family of Participant 4 had access to wifi and a cellular device. Informally, we note that many of our local Latino families leave to Mexico for the summer.

To overcome these barriers externally, it may help to choose intervention locations that are convenient for families, employ researchers that are culturally congruent, and studies that are low in risk and convenience (George, Duran, & Norris, 2014). This may look like going to the family's homes to delivery therapy, recruiting Latino researchers and volunteers, and providing services at no costs that would normally be charged. Internally, working in the child's dominant language where skills are the strongest, and using cognates (Grasso, et al., 2018) might help provide a stronger foundation for activities and generalization. Providing models during initial phases of treatment, consistency in sessions, and familiar routine might additionally aid in facilitating progress.

Implications of these finding are meaningful theoretically as well. The results offer further support for the interconnected nature of phonological systems versus autonomous ones. The children in this study were able to use the knowledge gained in their primary language for higher accuracy in their second language. This higher accuracy is consistent with the theory of cross-linguistic acceleration and single-category organization of similar sounds (Gildersleeve-Neumann & Goldstein, 2015; Paradis & Genesee, 1996).

This study offers converging evidence for generalization across previous treatment studies with bilingual children. We found skills learned in Spanish generalized into English for Spanish-English bilingual children with speech sounds disorders for targets that shared phonetic features across languages (Gildersleeve-Neumann & Goldstein, 2015). We found that skills generalized across types of disorders for motor-programming deficits (Gildersleeve-Neumann, 2015; Holm & Dodd, 2001), phonological delays (Gildersleeve-Neuman, 2015; Ray, 2002;), and articulatory delays (Holm & Dodd, 1997) when treatment methods were congruent with patterns of errors. Increased accuracy was seen for all items but was highest for targets that were stimulable (Rvachew & Nowak, 2001). We also saw accuracy was higher in the language of treatment, in this case Spanish (Gildersleeve-Neumann & Goldstein, 2015). We differ from previous studies by observing these patterns when only treating the L1. In summary, this and previous studies indicate that choosing targets that share phonetic features across treatment languages is a viable way to promote growth across languages for bilingual children with speech sound disorders.

5.5 Future Studies

We propose that the phonetic distinctions likely fall upon a spectrum of overlap that may promote generalization or transfer across languages. While it is possible to classify sounds in a binary fashion categorizing them as either shared or unshared, this distinction may not be so dichotomous. This is exemplified in Figure 5 where on the right are sounds that overlap completely in phonetic features and on the left are sounds share less features or are allophonic in nature. In addition, we propose those that are on the right are those sounds most likely to generalize from L1 to L2, on the left are sounds that are less likely to generalize, and in the middle are sounds that may generalize but fall somewhere in the middle. Conversely, those sounds that are least likely to generalize are most likely to be the product of transfer (i.e. substitutions) and those that are most likely to generalize are least likely to be susceptible to phonological transfer. Beginning to identify where sounds fall on this spectrum for language pairs could help us understand the likelihood that our goals will results in effects in the L2.

Additionally, future studies might extend this work by replicating this study in the nondominant language of the child. While previous studies have done work in the English, none so far have done so with rigorous experimental control or attempted in a fashion presented in the current study. The next step would be to demonstrate the reverse pattern of generalization from

English to Spanish. Interactional effects should be seen in a bidirectional manner. Additionally, we might even expect higher gains in English based on the initial level of accuracy seen in this study in English and the profile of the children involved. For children in our study, many of the English words were likely the equivalent of nonwords. Previous research has shown higher gains for work with nonwords over real words (Geirut & Morisette, 2010) in monolingual children.

Other language combinations where overlap exist may offer an opportunity to explore relationships of generalization cross-linguistically, too. Spanish and English have many sounds that overlap in phonetic features. In language pairs where there are more combinations such as between Spanish and Italian, we might expect more opportunities and greater generalization. In language pair where there are less, such as English and Mandarin, we might expect fewer opportunities. However, these predictions remain to be tested.

This study focused on sounds with high-levels of overlap and to date there is only one other study (Gildersleeve-Neumann & Goldstein, 2015) providing treatment data for Spanish-English children with speech sound disorders. In addition, for bilingual children with speech sound disorders, we have a database from across 4 studies of only 5 children to date. This study almost doubles that number providing data on 4 more for a total of 9. We argue the completion of any effort possible to advance our knowledge of how bilingual children respond to intervention should be valued and we encourage others to continue to research best practices in the area of treatment for bilingual children at any level possible.

Tables and Figures

Table 1

Phonemes Arranged by Level of Phonetic Similarity across Languages (adapted from Fabiano-Smith and Goldstein, 2010)

Class	Dissimilar to English (Spanish)	Phonetically Similar Across Languages	Dissimilar to Spanish (English)
Plosives		/p/ /b/ /t/ /d/ /k/ /g/	
Nasals	/ ɲ/	/m/ /n/	/ŋ/
Fricatives		/f/ /s/ /h/	/ θ/ /ʃ/ /ʒ/ /v / /ð/ /z/
Affricates		t͡ʃ	/d͡ʒ/
Liquids		/l/	
Rhotic			/ ɹ/
Flap	**/ɾ/**		
Trill	/r/		
Glides		/j/ /w/	

Table 2

Assessment Measures

Task	Purpose
Hearing Screening	To Determine if Hearing is within Normal Limits
Bilingual Input Output Survey	Determine Exposure Levels in each Language
Bilingual English Spanish Oral Screener	Screen Language Skills
Bilingual English Spanish Assessment	Assess Phonological, Morphosyntax and Semantic Skills across Spanish and English
Contextual Probes of Articulation Competence Spanish	Assess phonological skills for children 6 and over in Spanish (see below)
Narrative Tell based on Frog Stories	Complete language profile and identify sounds present in conversation
Stimulability Assessment	Assess potential treatment targets
Interview	Determine developmental history

Table 3

BESA English Phonology Cut-offs

Ages, English	Cut-offs	Sensitivity	Specificity
4	73	100%	93%
5	75	90.5%	89.9%
6	79	90.0	96.5

Table 4

BESA Spanish Phonology Cut-offs

Ages, Spanish	Cut-offs	Sensitivity	Specificity
4	71	100%	96.7
5	78	84%	93.1
6	69	66.7*	95.3

*Does not meet criteria

Table 5

CPAC-S Cut-offs

Cut-off	Sensitivity	Specificity
-1.5 SDs	98%	80%

Table 6

Assessment Summary, Participant 1

Language			*Domain*			
	Input/Output	Phonology	PCC	Morphosyntax	Semantics	MLUw
Spanish						
	56.5%	56 (CPAC-S)	75%	78	103	6.4
English						
	43.5%	<55 (BESA)	69%	50	50	3.3

Table 7

Stimulability Testing Results, Participant 1

Initial

/kra/ (+)	/kre/ ()	/kri/ (+)	/kro/ (+)	/kru/ ()
/akra/ (+)	/ekre/ (+)	/ikri/ ()	/okro/ ()	/ukru/ ()

Medial

/gra/ (+)	/gre/ (-)	/gri/ (+)	/gro/ (-)	/gru/ (-)
/agra/ (-)	/egre/ (-)	/igri/ (-)	/ogro/ (+)	/ugru/ (-)

/sa/ (-)	/se/ (-)	/si/ (-)	/so/ (-)	/su/ (-)
/asa/ (-)	/ese/ (-)	/isi/ (-)	/oso/ (-)	/usu/ (-)

Table 8

Assessment Summary, Participant 2

Language	*Domain*					
	Input/Output	Phonology	PCC	Morphosyntax	Semantics	MLUw
Spanish						
	84%	71 (CPAC-S)	88%	60	93	4.5
English						
	16%*	56 (BESA)	79%	60	n/a	3.1

*This likely underestimated her exposure, as parent (and not teacher) completed the school portion and she was enrolled in a dual-language curriculum

Table 9

Assessment Summary for Participant 3

Language	*Domain*					
	Input/Output	Phonology	PCC	Morphosyntax	Semantics	MLUw
Spanish	76%	65	73%	75	78	4.86
English	24%	75*	80%	58	62	1

*Some productions based off of imitation

Table 10

Stimulability Testing Target 1-3 Results, Participant 3

/sa/ (-)	/se/ (-)	/si/ (-)	/so/ (-)	/su/ (-)
/asa/ (-)	/ese/ (-)	/isi/ (-)	/oso/ (-)	/usu/ (-)
/as/ (-)	/es/ (+)	/is/ (-)	/os/ (o)	/us/ (+)
/as/ (-)	/ɛs/ (-)	/ɪs/ (-)	/oʊs/ (-)	/əs/ (-)
/pla/ (+)	/ple/ (-)	/pli/ (+)	/plo/ (-)	/plu/ (-)

Table 11

Assessment Summary, Participant 4

Language			*Domain*			
	Input/Output	Phonology	PCC	Morphosyntax	Semantics	MLUw
Spanish						
	61%	65	77%	62	93	2.5
English						
	39%	60	76%	*n/a*	*n/a*	1*

*based on limited productions

Table 12

Stimulability Testing Target 1 & 2 Results, Participant 4

/ tʃa/ (-)	/tʃe/ (-)	/tʃi/ (-)	/tʃo/ (-)	/tʃu/ (+)
/atʃa/ (-)	/etʃe/ (-)	/itʃi/ (-)	/otʃo/ (-)	/utʃu/ (-)
/pla/ (-)	/ple/ (-)	/pli/ (-)	/plo/ (-)	/plu/ (-)

Table 13

Hierarchy of Scaffolding

Level 1	Identification Task
Level 2	Sound level production with and without model (applicable to singletons only)
Level 3	Syllable Level with and without model (paired with errored pattern for clusters)
Level 4	Word Level Production with a model
Level 5	Word Level Production with an indirect model
Level 6	Word Level with a prompt
Level 7	Generalization Tasks (e.g. alternate speakers, phrases, etc)

Table 14

Pre- and Post-Test Results for Participant 1

	Spanish (C-PAC)		English (BESA)	
	Pre	Post	Pre	Post
Accuracy Measures				
Total Words Correct	25	45	6	13
Total Word Errors	39	19	25	18
PWC	61%	70%	19%	42%
Total Consonants Correct	134	160	52	74
Total Consonants in Error	45	19	45	23
PCC	75%	89%	54%	76%
Error Pattern				
/r/ Clusters	7/10	10/10	2/7	5/7

Table 15

Pre- and Post-Test Results for Participant 2

	Spanish (CPAC-S)		English (BESA)	
	Pre	Post	Pre	Post
Accuracy Measures				
Total Words Correct	48	56	10	21
Total Words in Error	16	8	21	10
PWC	75%	96%	32%	68%
Consonants Correct	159	171	77	85
Consonants in Error	20	8	20	12
PCC	89%	96%	79%	88%
Error Patterns				
Multisyllabic Words Correct	0/4	4/4	0/6	4/6

* 3+ syllables Eng; 4+ in Span

Table 16

Pre- and Post-Test Results for Participant 3

	Spanish (BESA)		English (BESA)	
	Pre	Post	Pre	Post
Accuracy Measures				
Total Words Correct	8	18	12	15
Total Words in Error	20	10	19	16
PWC	29%	64%	39%	52%
Consonants Correct	68	82	78	80
Consonants in Error	25	11	19	17
PCC	73%	88%	80%	82%
Error Patterns				
Stopping	0/5	0/5	0/7	0/7
Cluster Reduction	1/10	9/10	3/10	9/10

Table 17

Pre- and Post-Test Results for Participant 4

	Spanish (BESA)		English (BESA)	
	Pre	Post	Pre	Post
Accuracy Measures				
Total Words Correct	8	9	8	14
Total Words in Error	20	19	23	17
PWC	29%	32%	26%	45%
Consonants Correct	71	74	74	80
Consonants in Error	21	18	23	17
PCC	77%	80%	76%	82%
Error Patterns				
Cluster Reduction*	0/10	8/10	4/10	9/10
Affricates	0/1	0/1	0/3	1/3

*Accepting glides as correct (e.g. [pw]); includes both /r/ and /l/ clusters

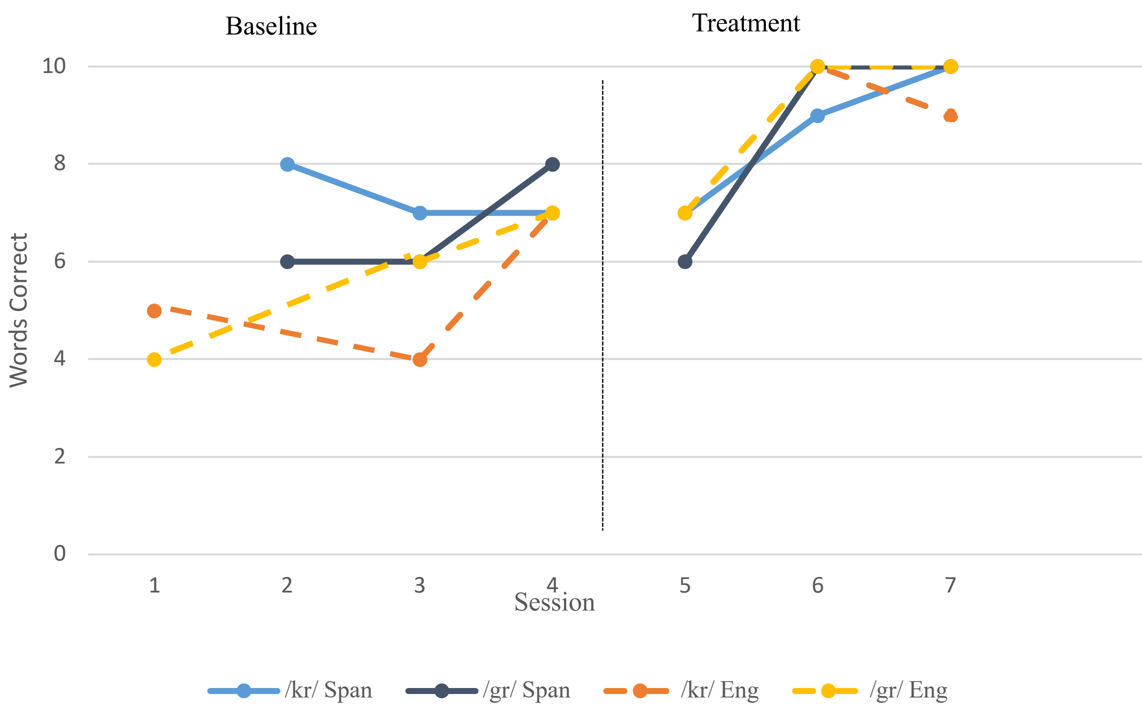

Figure 1. Probe Data for Participant 1

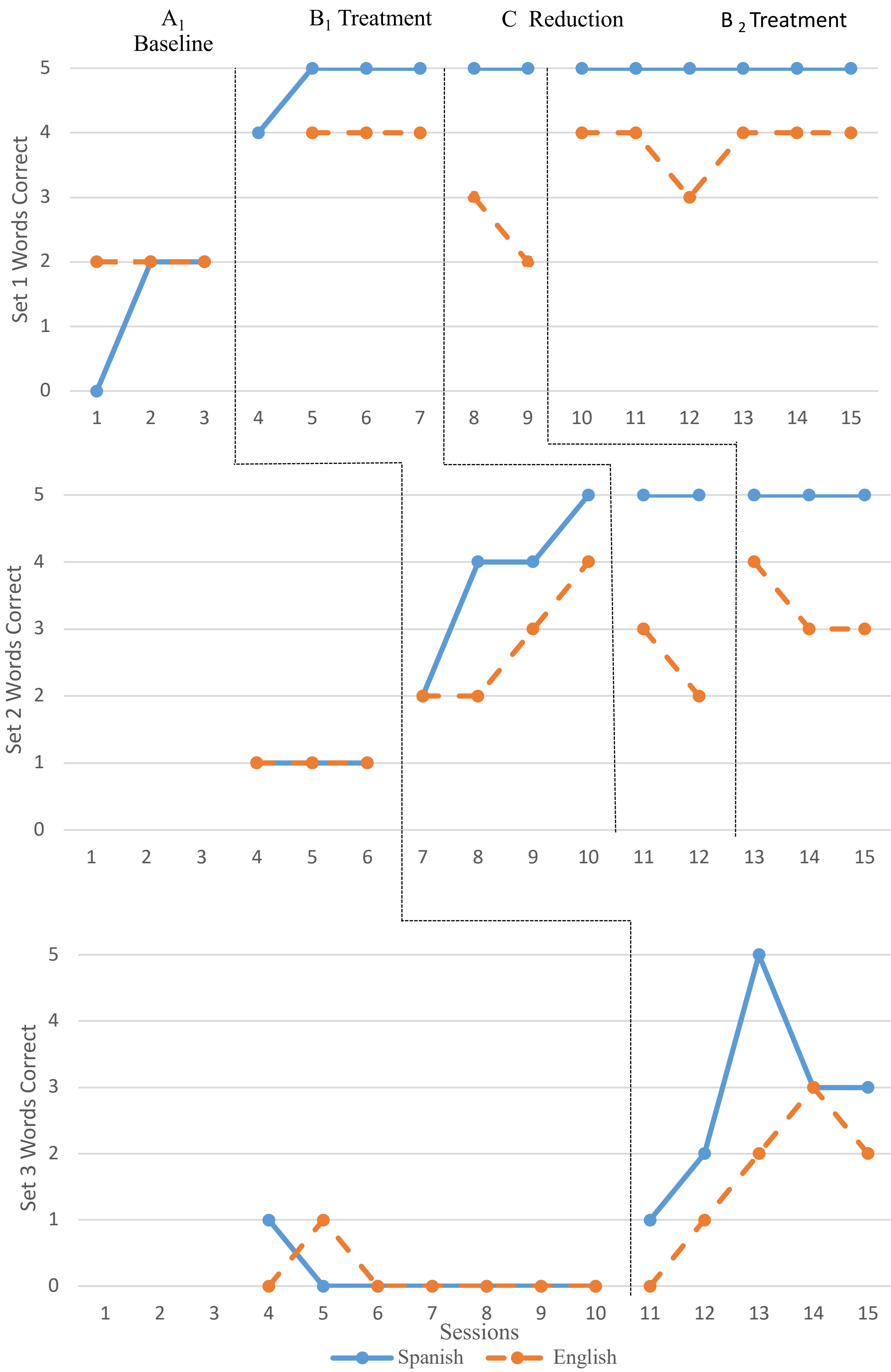

Figure 2. Probe Data for Participant 2

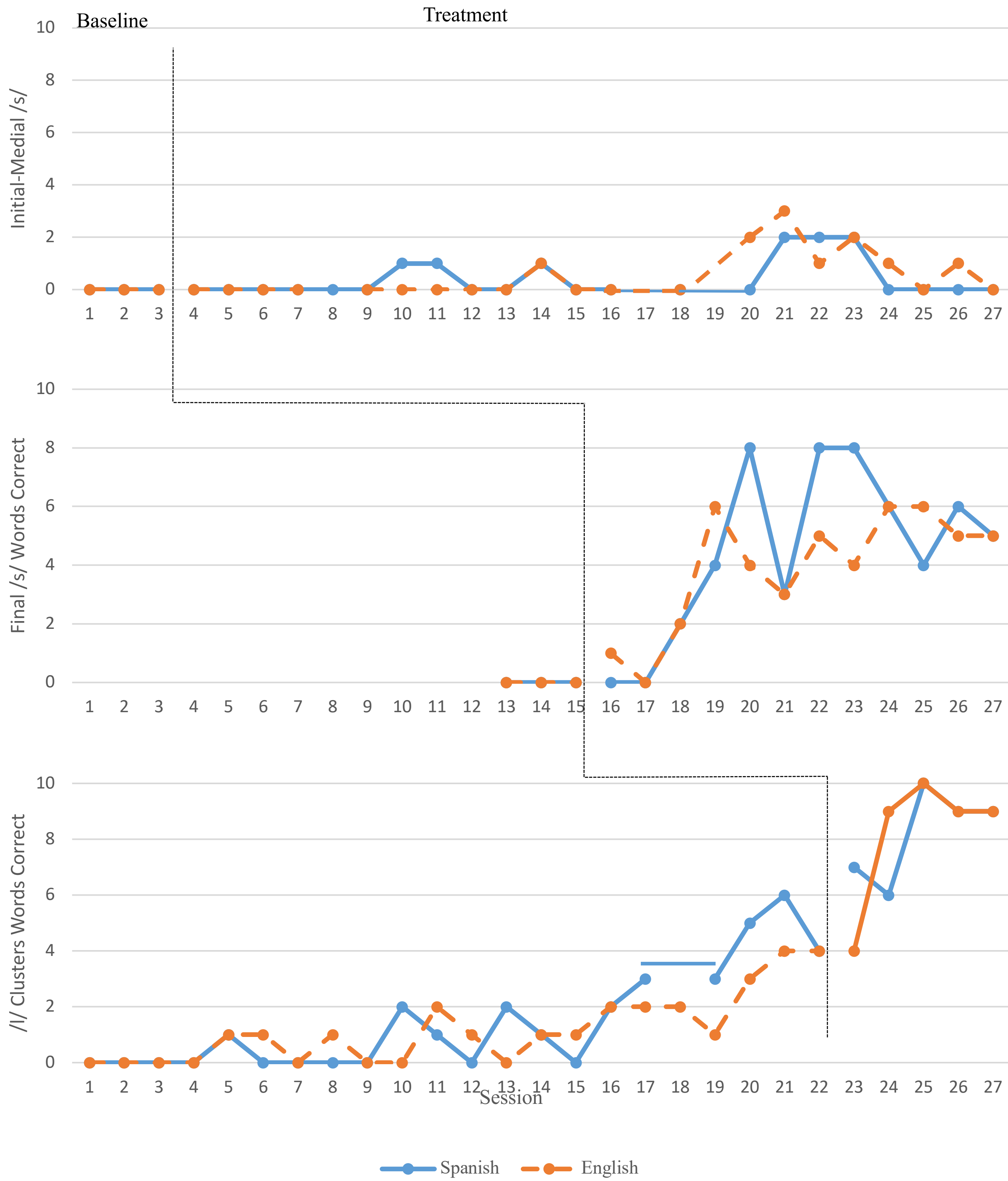

Figure 3. Probe Data for Participant 3

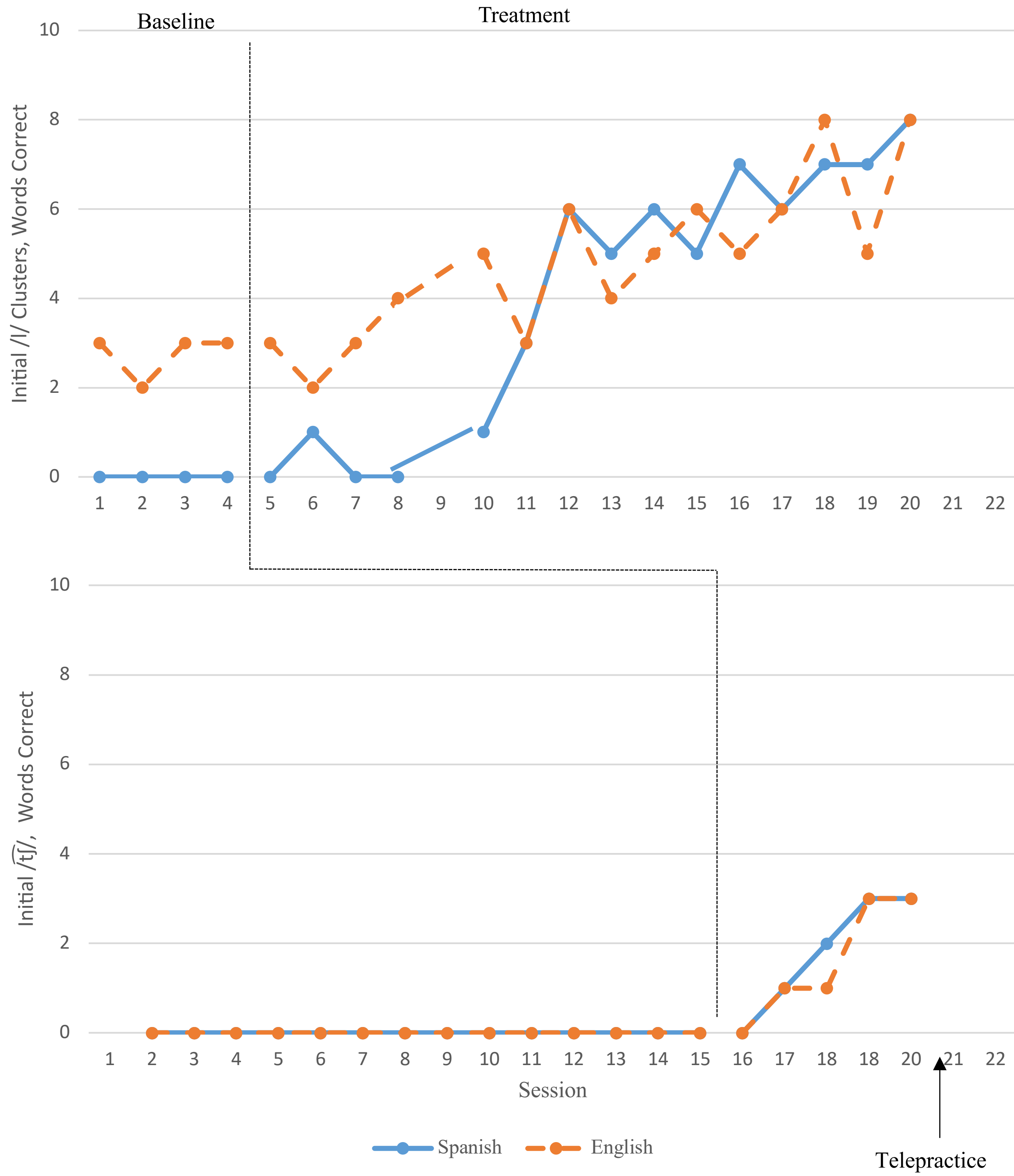

Figure 4. Probe Data for Participant 4

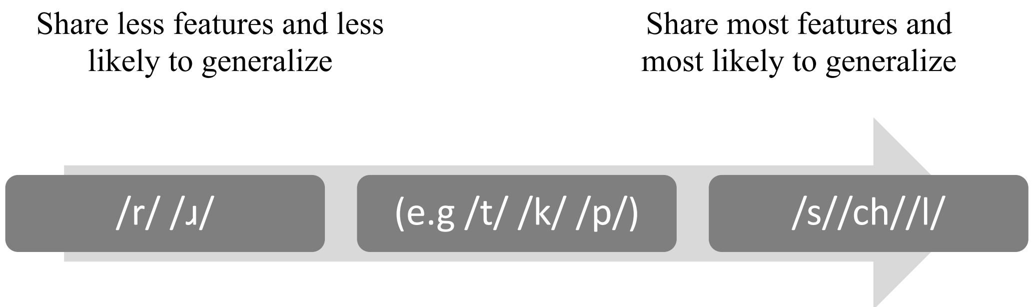

Figure 5. Spectrum of Generalization

Appendices

Appendix 1: General Stimulability Stimuli

Syllabic Shape*

Spanish

/Ca/	/Ce/	/Ci/	/Co/	/Cu/
/aCa/	/eCe/	/iCi/	/oCo/	/uCu/
/as/	/es/	/is/	/os/	/us/

*Probed as applicable to goals

Appendix 2: Probe Stimuli for Participant 1

Target 1 Items List

Item	*Spanish*	*English*
1	*Cruzar*	Crown
2	*Cruz*	Crowd
3	*Craneo*	Crawl
4	*Creyón*	Crow
5	*Cresta*	Crayon
6	*Criada*	Crab
7	*Crin*	Cry
8	*Crucero*	Cracker
9	*Crema*	Crash
10	*Croar*	Crib

Target 2 Items List

Item	*Spanish*	*English*
1	*Grieta*	Green
2	*Grupo*	Grapes
3	*Granja*	Grass
4	*Grúa*	Grandma
5	*Grillo*	Grade
6	*Grande*	Grow
7	*Granjero*	Ground
8	*Grados*	Growl
9	*Grapadora*	Group
10	*Grabadora*	Grey

Appendix 3: Probe Stimuli for Participant 2

Set 1 Targets List

Spanish Word (syllables)	*Cognate (syllables)*
Mandarina (4)	Mandarin (3)
Pelicano (4)	Pelican (3)
Cocodrilo (4)	Crocodile (3)
Gorila (3)	Gorilla (3)
Banana (3)	Banana (3)

Set 2 Targets List (Multisyllabic Words Primarily with Final Consonants)

Spanish Words (Syllables)	*Cognate (Syllables)*
Diagonal (3)	Diagonal (4)
General (3)	General (3)
*Hipopótamo (5)	Hippopotamus (5)
Horizontal (4)	Horizontal (4)
Televisión (4)	Television (4)

Set 3 Targets List (Clusters and Final Consonants)

Spanish Words (Syllables)	*Cognate (Syllables)*
Experimental (5)	Experimental (5)
Explosión (3)	Explosion (3)
Flexible (3)	Flexible (3)
Construcción (3)	Construction (3)
Instrucciones (4)	Instructions (3)

Appendix 4: Probe Stimuli for Participant 3

Target 1 Items List

Item	*Spanish*	*English*
1	*Sarta* (string) / *Tarta (cake)*	sun
2	*Cinta* (tape) / *Tinta* (ink)	sit
3	*Sierra* (saw) / *Tierra* (earth)	soap
4	*Rosa* (rose) / *Rota* (broken)	soup
5	*Piso* (floor) / *Pito* (whistle)	sock
6	*Foso* (hole) / *Foto* (picture)	whistle
7	*Paso* (step) / *Pato* (duck)	muscle
8	*Plaza* (plaza) / *Plata* (silver)	listen
9	*Falsa* (false) / *Falta* (miss)	messy
10	*Salta* (jump) / *Salsa* (sauce)	baseball

Target 2 Items List

Item	*Spanish*	*English*
1	*Dos* (two)	Ice
2	*Luz* (light)	Face
3	*Pez* (fish)	Mice
4	*Diez* (ten)	Cactus
5	*Bus* (bus)	Rice
6	*Lápiz* (pencil)	Horse
7	*Lentes* (glasses)	Grass
8	*Tijeras* (scissors)	Yes
9	*Flores* (flowers)	House
10	*Platos* (plates)	Geese

Target 3 Items List

Item	*Spanish*	*English*
1	*Playa* (beach) / *paya* (campesina)	Blow
2	*Globo* (balloon) / *gobo* (**nonce**)	Clap
3	*Plancha* (iron) / *pancha* (tummy)	Glass
4	*Flote* (float) / *fote* (**nonce**)	Glow
5	*Clima* (climate) / *kima* (**nonce**)	Plate
6	*Clava* (club) / *cava* (dig)	Clown
7	*Plana* (flat) / *pana* (fabric)	Floor
8	*Plata* (silver) / *pata* (leg)	Plane
9	*Flaca* (thin) / *faca* (knife)	Play
10	*Plazo* (payment) / *paso* (step)	Blocks

Appendix 5: Probe Stimuli for Participant 4

Target 1 Items List

Item	*Spanish*	*English*
1	*Playa* (beach) / *Laya* (spade)	Blow
2	*Globo* (balloon) / *Lobo* (wolf)	Clap
3	*Plancha* (iron) / *Lancha* (barge)	Glass
4	*Flote* (float) / *Lote* (lottery)	Glow
5	*Clima* (climate) / *Lima* (lime)	Plate
6	*Clava* (club) / *Lava* (wash)	Clown
7	*Plana* (flat) / *Lana* (wool)	Floor
8	*Plata* (silver) / *Lata* (can)	Plane
9	*Flaca* (thin) / *Laca* (hair spray)	Play
10	*Plazo* (payment) / *Lazo* (lasso)	Blocks

Final Target 1 Items List

Item	*Spanish*	*English*
1	*Playa* (beach) / *paya* (campesina)	Blow
2	*Globo* (balloon) / *gobo* (**nonce**)	Clap
3	*Plancha* (iron) / *pancha* (tummy)	Glass
4	*Flote* (float) / *fote* (**nonce**)	Glow
5	*Clima* (climate) / *kima* (**nonce**)	Plate
6	*Clava* (club) / *cava* (dig)	Clown
7	*Plana* (flat) / *pana* (fabric)	Floor
8	*Plata* (silver) / *pata* (leg)	Plane
9	*Flaca* (thin) / *faca* (knife)	Play
10	*Plazo* (payment) / *paso* (step)	Blocks

Target 2 Items List

Target	*Spanish*	*English*
1	*Chorizo* (sausage)	Chain
2	*Chivo* (goat)	cheese
3	*Chicle* (gum)	chihuahua
4	*Chocolate* (chocolate)	chili
5	*Champú* (shampoo)	cherries
6	*Chimenea* (chimney)	chips
7	*Charco* (puddle)	chicken
8	*Chancla* (sandle)	check
9	*Cheque* (check)	Chocolate
10	*Chamarra* (jacket)	children

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